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Southwest

FISHERIES CENTER

HONOLULU

LA JOLLA

MONTEREY

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REPORT OF ACTIVITIES

November-December 1988

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COASTAL FISHERIES RESOURCES DIVISION

La Jolla, California

COASTAL EASTERN PACIFIC POPULATION BIOLOGY OF FISHES

Introduction

Biological Technician Sharon Kramer recently summarized the key findings of the second year of a 2 year inshore fish survey conducted by the Southwest Fisheries Center task, Southern California Wetland/Shallow Water Habitat Investigations.

Juvenile White Sea Bass

A total of 75 newly metamorphosed white sea bass was captured between May and September 1988. Most of these fish were taken in July in shallow water along the open coast. They were taken in water less than 8 m deep, just outside the breaker line. This habitat is typically sandy with substantial quantities of decomposing drift algae and high standing stocks of crustacea that are potential forage for the young sea bass.

The mean length of juveniles captured in July was 23 mm SL. The average density of white sea bass juveniles in July was 22/hectare for shallow water coastal habitat between Mission Bay and San Onofre. This shallow water habitat represents approximately 1/3 of the total coastal study area, or 2270 hectares ($0.33 \times 6880 = 2270$). The number of juvenile white sea bass present in shallow water (depth 0 to 8 m) along 40 nm of coastline is about 47,700 juveniles ($2270 \text{ hectares} \times 22/\text{ha} = 47,700$). This estimate is similar to the July 1987 estimate of 32,000 juveniles for the same area. Preservation of this shallow coastal habitat appears to be important for white sea bass survival.

San Diego Bay

The habitats of San Diego Bay were sampled during one 2-week period (June 20 to July 5, 1988). During this period, the density of juvenile California halibut (SL 50 mm) in San Diego Bay was much lower than that in Agua Hedionda, Mission Bay, or along the open coast (number/hectare=4, 145, 24, and 11, respectively). Of the 15,000 halibut estimated to occur in San Diego Bay, nearly 11,000 were from dredged habitats

(depths greater than 6 m) representing nearly half of the total area of the bay relative to other areas (about 1600 hectares). The low abundance and density of halibut in San Diego Bay could be caused by affects of dredging, pollution, or by a difference in the timing of settlement in San Diego Bay relative to other areas. The latter explanation seems the least likely; a time series would be required to reach a definite conclusion. (S. Kramer, FTS 893-7105)

New Aquarium Technician Hired

Fishery Biologist Gail Theilacker has hired Larry Robertson, Biological Technician, to maintain the broodstocks of sablefish and Dover sole in the SWFC aquarium. Robertson, who most recently has been associated with the Observer Program, has an extensive background in maintaining healthy brood stocks of fishes, inducing spawning, rearing fish larvae, and culturing their foods. Theilacker, Robertson, and Eric Lynn, Fishery Biologist, will survey the sablefish in the aquarium this month and, if fish are mature, will begin hormone injections to induce spawning.

Height of Midgut Cells Defines Condition of Larval Anchovy

Theilacker completed a manuscript with Yoshiro Watanabe, Tohoku Regional Fisheries Research Laboratory, Shiogama, Mihagi, Japan, which she will submit to the Fishery Bulletin Festschrift issue that is dedicated to Reuben Lasker. Lasker believed that a major cause of larval mortality is starvation, and Theilacker's manuscript, "Midgut cell height defines nutritional status of laboratory-raised larval northern anchovy, *Engraulis mordax*," describes a diagnostic index which can be used to assess the past feeding of the larvae and identify starving larvae. Theilacker and Watanabe compared the midgut index to traditional histological indices and tested the index for field use. The midgut height index was much easier and faster to measure than scoring the histological features of anchovy tissues and it does not require a solid background in histology for the person scoring. The index was sensitive, yielding reliable estimates of larval condition. It will be useful and practical for field work because it was dependable in formalin-fixed tissue, and unlike other diagnostic criteria, resistant to autolysis (withstands prolonged time in collecting net). Thus, the midgut index is practical for routine estimates of starvation rates of larvae in the sea. In addition, unlike previous

methods, the duration of tow is not a constraint because the character does not degrade with time and a sample representative of the water column can be taken. (G. Theilacker, FTS 893-7125)

New Approach to Demersal Fish Assessment

Fishery Biologist Dr. John Butler has submitted a proposal to the National Undersea Research Program, NOAA, to develop new methods of assessing the biomass of demersal fishes. The proposal would combine new technology and existing high resolution bathymetric surveys to produce more precise estimates of fisheries resources.

Presently, demersal fish survey techniques are limited to swept area trawl surveys and egg production surveys. Trawl surveys are limited to soft substrate of considerable extent because trawls require a minimum of one mile of flat terrain. Egg production techniques are also dependent upon bottom trawling for spawning rate estimates. If densities and or biological parameters in trawlable areas are unrepresentative of the population as a whole, then biomass estimates and management decisions are in error.

The proposed work would combine photographic and sidescan sonar assessment with Seabeam surveys of habitat type. Photographic and sidescan sonar surveys from an ROV would provide density estimates in habitats unsampled by conventional trawling. Seabeam surveys would determine the areal extent of trawlable and untrawlable habitat. Biomass estimates would be determined from densities and the areal extent of each habitat. (J. Butler, FTS 893-7149)

COASTAL EASTERN PACIFIC FISHERIES ENVIRONMENTAL INVESTIGATIONS

A New U.S. Tuna Fishery - Jig Fishing for South Pacific Albacore Excellent in 1988, More Boats to Fish in 1989

A new albacore tuna fishery for U.S. jigboats has been successfully developed in the central South Pacific Ocean. Over 40 U.S. jigboats participated in the fishery in 1988, along with several jigboats from Canada, Tahiti and Fiji. Approximately 4,500 tons of albacore were caught. Fish were landed at canneries in Pago Pago, American Samoa and near Suva, Fiji, and for trans- shipping in Papeete, Tahiti.

Approximately 55 jigboats are fishing in the new albacore fishery in the South Pacific in 1989. About 45 of these vessels departed from U.S. ports in November and December 1988 to travel to the fishing grounds in the central South Pacific. The remainder of the vessels are from Canada, New Zealand, Tahiti and Fiji. Early reports are that fishing has been good to excellent in the same general areas as in early 1988.

The new fishery has resulted from exploratory fishing and scientific surveys conducted in 1986 and 1987 by the U.S. albacore fishing industry, through the American Fishermen's Research Foundation (AFRF), and the NOAA Southwest Fisheries Center (SWFC). A portion of the exploratory fishing operations conducted by the fishing vessels was funded by Saltonstall- Kennedy (S-K) funds awarded to the AFRF through the NOAA Southwest Fisheries Region (SWR).

Background Information

The U.S. albacore fishery has operated in the eastern North Pacific for over 75 years. Traditionally, virtually all of the catches have been sold to U.S. canneries. The closures in the early 1980's of all but one of the tuna canneries located along the U.S. west coast and Hawaii caused concern to fishermen. Should the sole remaining domestic cannery also close, fishermen would have great difficulty in marketing catches, and there would be high risks of losing their means of livelihood. In response to the situation, U.S. albacore fishermen sought to find alternative markets for their catches from the North Pacific and to evaluate new areas to fish.

The central South Pacific appeared to hold potential as a new area for U.S. albacore jigboats to operate. The South Pacific albacore resource has supported a substantial Asian longline fishery since the early 1950's. This fishery caught mainly large, adult fish at considerable depth. However, the younger, smaller fish in the population remained unexploited, except for a small fishery in New Zealand coastal waters. There was also the infrastructure in Pago Pago for selling catches to U.S. canneries, refueling, making repairs and reprovisioning.

SWFC scientists summarized existing albacore fishery, oceanographic, and weather information from the South Pacific. Using this information and knowledge about the habitat and migration patterns of albacore acquired

from research conducted in the North Pacific, they formulated hypotheses concerning albacore availability and migration in the South Pacific. A sampling protocol was developed to test the hypotheses (1) that during austral summer the younger, smaller fish in the population would be distributed mainly in South Pacific Subtropical Convergence Zone (STCZ) waters and migrating eastward, and (2) that the fish would be most vulnerable to jigfishing near oceanic fronts marking the boundaries of the STCZ waters.

Exploratory fishing and scientific surveys were conducted during 1986 by SWFC and visiting scientists onboard the NOAA R/V *Townsend Cromwell* working in conjunction with two U.S. jigboats in central South Pacific waters and with the New Zealand R/V *Kaharoa* in western South Pacific waters. The activities were expanded in scope, participation and coordination in 1987 as the result of recommendations made at the first South Pacific Albacore Research Workshop held in Auckland, New Zealand in June 1986. In 1987 the R/V *Townsend Cromwell* conducted extensive oceanographic and biological observations in the central South Pacific in accompaniment with seven U.S. jigboats that carried on exploratory fishing and scientific operations. These activities were coordinated with research vessel operations conducted by New Zealand scientists in the western South Pacific and French scientists in the eastern South Pacific.

The results from the 1986 and 1987 surveys showed that the prospects were excellent for establishing a jigfishery on albacore in the South Pacific. The high catch rates, high total catches and relatively good weather conditions, combined with the infrastructure in the South Pacific for selling catches and supporting fishing vessel needs, demonstrated that it is economically feasible for U.S. albacore fishing vessels to operate there. The experience of the jigboats that fished for albacore in the South Pacific during 1988 substantiate this conclusion.

Albacore fishing by Jigboats in the Central South Pacific in 1988

Amount of Catch. Approximately 4,500 tons of albacore were landed in 1988 by jigboats operating in the central South Pacific. The average catch per boat was about 100 tons. A small number of boats arrived in the fishing area

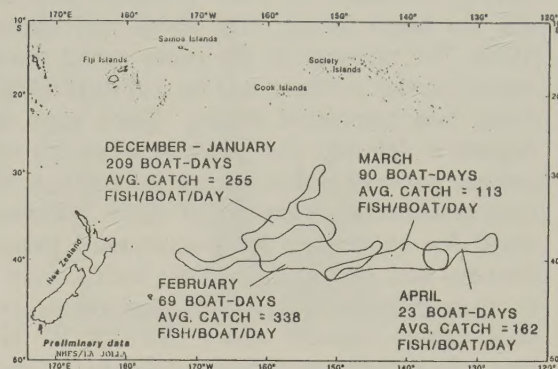


Figure 1. Albacore jig fishing areas in the central South Pacific in 1987-1988.

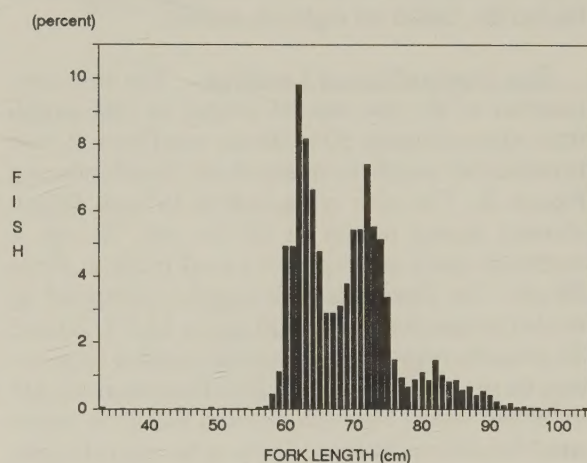


Figure 2. Size composition in centimeters of albacore landed from the central South Pacific by jigboats during 1988.

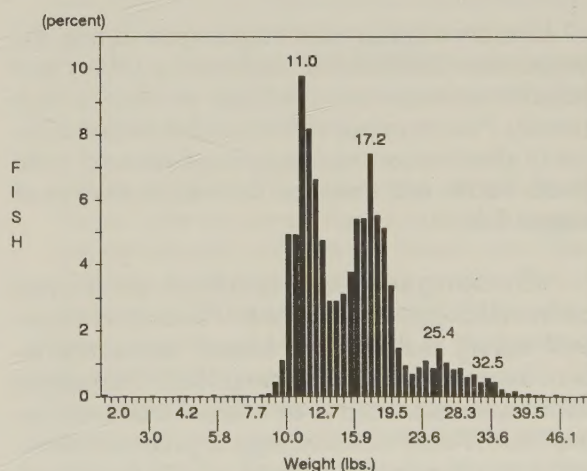


Figure 3. Size composition in pounds of albacore landed from the central South Pacific by jigboats during 1988.

during mid-December 1987, however, most boats did not begin fishing until about mid-January 1988. The majority of the boats fished through about the end of March and by mid-April all of the boats had completed fishing. Catch rates were highest in January and February when the mean catches per boat per day exceeded 250 fish. Most catches were made between 38°-42°S. There was a trend for catches to shift southward between January and March and slightly back toward the north in April. The vessels fished over a broad range of longitude between about 170°-125°W. There was a distinct shift in fishing success to the east as the season progressed, suggesting an eastward migration of the fish. Figure 1 is a schematic drawing showing the areas fished and mean catch rates by month, based on logbook records.

Size Composition of Landings. The size composition of the fish landed ranged in fork length from approximately 60 to 95 cm, see Figure 2, and in calculated weight from about 6 to 50 pounds, see Figure 3. The size composition in fork length showed strong modes at 62 cm and 72 cm, a moderate mode at 82 cm and a weak mode at about 89 cm. The modes in fork length correspond to modes in calculated weight at about 11, 17, 25 and 32 pounds, respectively. Because of price differentials by weight paid for the fish, fishermen tended to "shake" small fish and/or avoid locations where small fish were prevalent. There appeared to be little temporal variation in the size composition of the fish landed, even though there was considerable variation in location of fishing during the season, see Figure 1.

Tagging

Albacore tagging was emphasized during the cooperative NMFS/AFRF exploratory fishing and scientific surveys and continues to have a high priority. Prior to present efforts, only a limited number of albacore had been tagged and released in the South Pacific and there had been no recoveries of tagged fish.

Albacore tag and release operations were carried on from U.S. jigboats and the R/V *Townsend Cromwell* during the albacore fishery exploration/research survey conducted in early 1986. The tagging efforts were expanded to an international cooperative South Pacific albacore tagging program following a recommendation made at the first South Pacific Albacore Research Workshop. The overall objective of the tagging program is to develop knowledge needed to fully develop the fisheries on

the South Pacific albacore resource and ensure the viability of the resource. Data on migratory patterns, age and growth, and fisheries interactions are especially important.

Release Information. U.S. albacore fishermen have continued to tag and release albacore during fishing operations in the South Pacific. As has been done in the North Pacific since the early 1970's, tagging equipment and training are provided to albacore fishermen by SWFC scientists. Tagging records are then provided to the SWFC. Fishermen were reimbursed by the SWFC and SWR for South Pacific albacore tagged during the 1988 fishing season. During the 1989 fishing season, U.S. fishermen are scheduled to tag and release an additional 1,500 albacore. They will receive reimbursement for the fish released from S-K funds awarded to AFRF and from AFRF funds. Tagging also continues to be stressed by New Zealand fishery scientists, who are responsible for tagging about one-third of the total number of South Pacific albacore that have been tagged and released.

Through the 1988 fishing season, nearly 3,500 albacore have been tagged and released in the South Pacific. A summary of the number of albacore tagged and released by year and type of operation is given in Table 1.

Table 1. Number of albacore tagged and released in the South Pacific, 1986-1988.

Vessel	1986	1987	1988	Total
U.S. fishing vessels	702	886	248	1836
R/V <i>Townsend Cromwell</i>	21	425	—	446
R/V <i>Kaharoa</i> (New Zealand)	138	178	625	941
N.Z. fishing vessels	—	70	—	70
R/V <i>Coriolis</i>	—	190	—	190
Total	861	1749	873	3483

Virtually all of the tagging by U.S. fishermen and scientists has been conducted in the central South Pacific between about 170°-140°W and 38°-41°S. Most of the tagging by New Zealand fishery scientists has been in nearshore waters off the west and east coasts of the New Zealand north island and in the vicinity of the Chatham Islands. Information is summarized in Figure 4 on the number of albacore tagged by 1° quadrangle during 1986 through 1988.

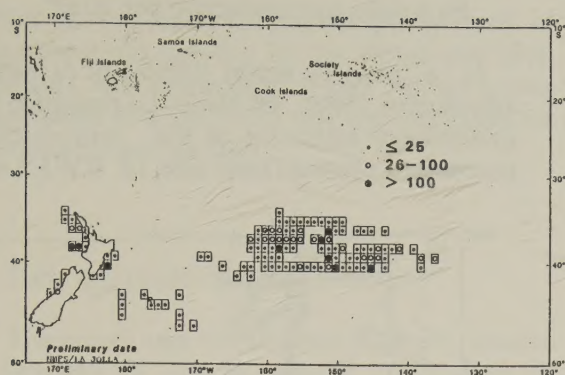


Figure 4. Summary of albacore tagged and released in the South Pacific.

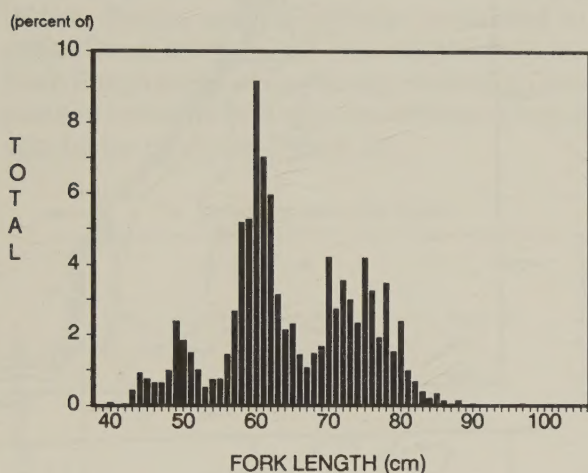


Figure 5. Size composition of albacore tagged and released in the South Pacific (1986-1988).

The combined length frequency for fish that have been tagged and released in the central and western South Pacific, sans those released by the French, is shown in Figure 5. The modes are generally representative of albacore landed by the combined jig fisheries that operate in these regions. Plots of the length frequencies for fish tagged east and west of 170°W (given in Figures 6 and 7, respectively), show that relatively few small fish, less than about 55 cm have been tagged in the central region. This may in part be due to "sampling", since U.S. fishermen avoid areas where small fish are prevalent because the price is lower for fish less than 11 pounds.

Recovery Information. Four fish released in the central South Pacific and one released off the east coast of the New Zealand north island have been recovered by the Asian longline fisheries. Information on the tag recoveries is given in Figure 8 where

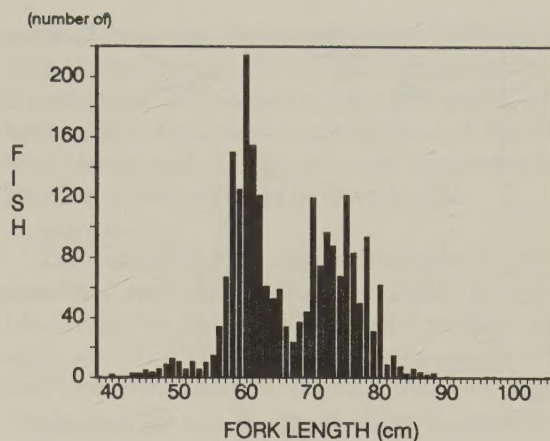


Figure 6. Size composition of albacore tagged and released in the South Pacific, east of 170°W (1986-1988).

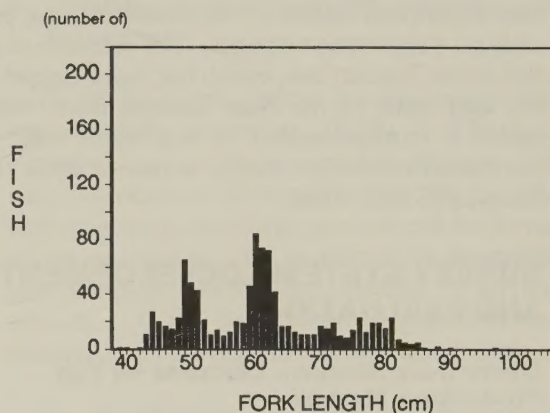


Figure 7. Size composition of albacore tagged and released in the South Pacific, west of 170°W (1986-1988).

the black dot shows the location of release, the head of the arrow marks the location of recovery, the number nearest the head of the arrow is the number of days that the tagged fish was at liberty, and the number in parentheses was the fork length at time of release.

Two of the fish tagged in the central South Pacific were recovered during austral late summer months east of the sites of release after being at liberty for 2 months and 13 months. Two of the tagged fish were recovered during austral winter months, generally north of the locations of release after being at liberty for about 1-1/2 years and 2-1/2 years. These recovery results, along with the size (age) of the fish at time of release, suggest the possibility that immature fish move eastward across the central South Pacific in Subtropical Convergence Zone (STCZ) waters

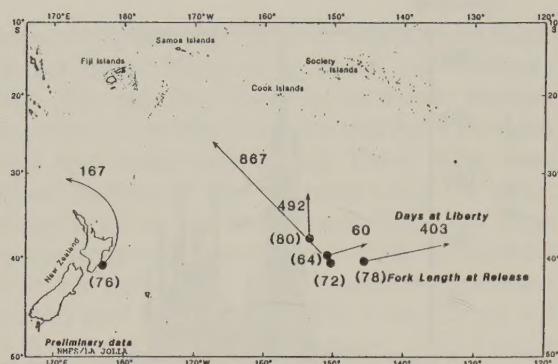


Figure 8. South Pacific albacore tag recoveries.

during summer months, presumably on a feeding migration, and that mature fish move northward into subtropical waters during winter months, possibly on a spawning migration. The recovery of the fish in the Tasman Sea, which had been tagged off the east coast of the New Zealand north island about 6 months earlier, is consistent with the northward movement during winter months. (M. Laurs, FTS 893-7086)

SURVEY SYSTEMS DEVELOPMENT AND EVALUATION

Dover Sole Biomass Estimate by Egg Production Method

In 1987, The Coastal Fisheries Resources Division (CFRD) began a study to estimate the biomass of the Dover sole population in California coastal waters using egg production and swept trawl methodologies. Two surveys of central California waters (8701, 8803) have been completed. The survey extended from Pt. Conception to Monterey Bay (Figure 9). Adult Dover sole and their planktonic eggs were sampled and used to estimate their rates of reproduction and ultimately their biomass. The basic model for the daily egg production method (EPM) is:

$$B_a \cdot (R/W) \cdot (F \cdot S/d) = P_0 \cdot A$$

where B_a is the biomass (mt) for area A

R is female fraction of population by weight

W is average female weight (gm)

F is total fecundity for average female weight

S is fraction of female with active ovaries for average female weight

$F \cdot S/d$ is number of eggs per female per day

P_0 is daily egg production per 10 m^2 .

In a previous report (Report of Activities, July-August 1988), Dr. Nancy Lo presented the preliminary estimates of the reproductive parameters of adult Dover sole, i.e. R, W, F, S and

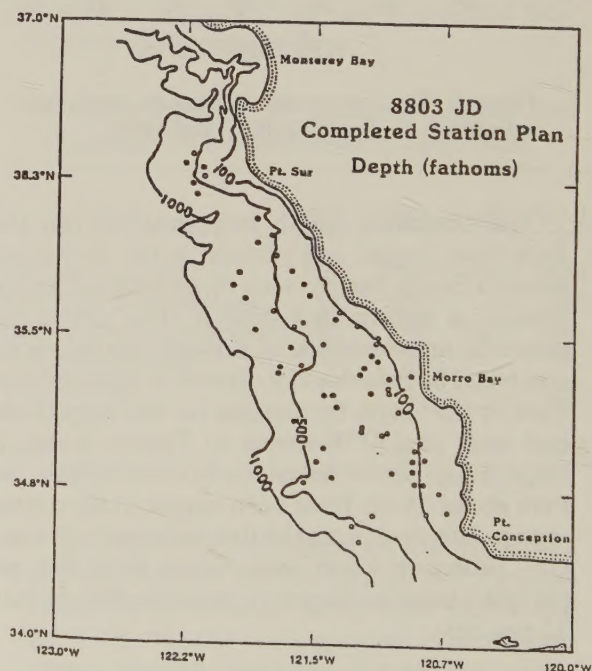
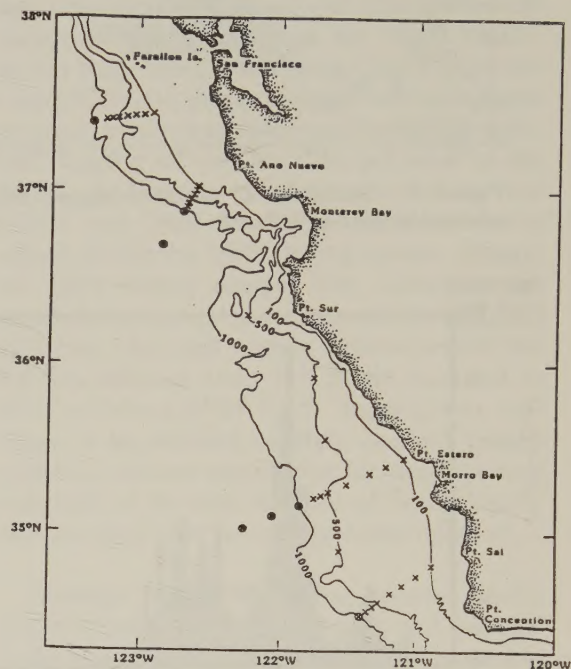


Figure 9. Survey area of Dover sole cruises 8701 (January 8- February 17) and 8803 (February 22-April 10). The survey pattern for 8701 is line transect sampling and for 8803 is random sampling.

F*S/d. In this report Lo presents the estimates of eggs produced per day for the Dover sole (P_0), updates the estimates of the reproductive parameters of adult Dover sole and computes the estimate of biomass (B_a).

1. Daily egg production per 10 m²

The survey area was stratified by depth: stratum 1 (≤ 249 fm, 456 m), stratum 2 (250–549 fm, 457–1004 m) and stratum 3 (≥ 550 fm, 1005 m). Similar to adult samples, most of the eggs were found in strata 2 and 3. Three plankton net types (Manta, Bongo, and Deep Bongo) were used to collect Dover sole eggs but only samples from the Deep Bongo were used in the egg production computation because of the apparent undersampling of eggs by the other nets (Figure 10).

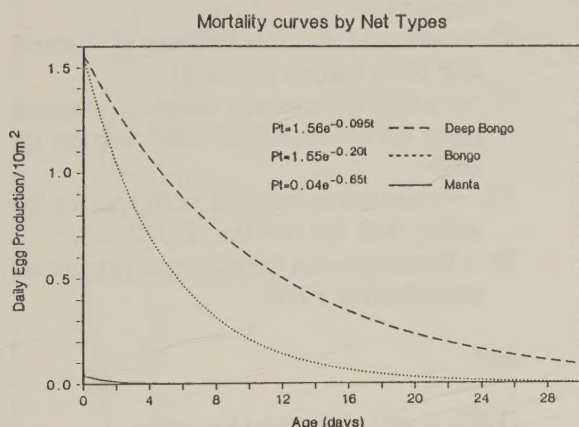


Figure 10. Mortality curves based on egg data collected from three net types: Manta, Bongo, and Deep Bongo, 1987–1988.

The mortality curve was assumed to be negative exponential:

$$P_t = P_0 \exp(-zt)$$

P_t is the daily egg production per 10 m² at age t

P_0 is the daily egg production per 10 m² at age 0

z is the daily instantaneous mortality rate

t is the age (day).

All the eggs were first staged according to their morphological characteristics and were aged according to a temperature dependent stage-to-age algorithm. This algorithm was based on: 1) An experiment on age of staged eggs at 5.9°C conducted by Dr. Geoff Moser where 109 eggs were

sampled from eggs incubated aboard the NOAA Ship *David Starr Jordan* by Eric Lynn and continued at the SWFC during the 1988 cruise; 2) temperature dependent hatching time of North Sea plaice; and 3) the average temperature above and below 200 m in Deep Bongo.

The number of eggs were also adjusted by the standard haul factor for the Deep Bongo (developed by Paul Smith) to yield number of eggs per 10 m². The number of eggs per 10 m² and age were used to estimate the daily egg production ($P_0 = 1.56$ (se=0.18)) and the daily egg mortality rate ($z=0.095$ (se=0.016)).

2. Updates of adult parameter estimates and the biomass

In the previous report Lo presented the specific daily fecundity ($(R/W) * (F*S/d) = \text{eggs/gm-day}$) as the unstratified average for each reproductive adult parameter. As the difference among strata was pronounced for some of the parameters, the specific daily fecundity was computed within each stratum: 0.047 for stratum 1, 0.146 for stratum 2, and 0.49 for stratum 3. The weighted average was 0.128.

The daily EPM biomass estimate of Dover sole in central California for 1987–88 was computed as:

$$B_a * 0.128 * 10^6 = (1.56/10) * 14,172 * 10^6$$

$$\text{and } B_a = 17,272 \text{ mt.}$$

The biomass estimate from daily EPM is similar to the biomass estimate (19,400 mt) from the swept trawl method for 1988 (J. Butler).

The results of application of daily EPM to the Dover sole are encouraging and demonstrate that the method is practical for Dover sole and may be applicable to other groundfish. Some uncertainties remain, however. We need to know the vertical distribution of Dover sole eggs in the water column and their rate of incubation at various temperatures. In addition, we need to better define the offshore boundary and north-south transport of eggs within a survey area and to determine the effects of latitude and season on production of eggs by Dover sole population. (N. Lo, FTS 893-7123)

COMMERCIAL AND RECREATIONAL FISHERIES RESEARCH FOR MANAGEMENT

Economics Planning, Studies and Activities

Dr. Dan Huppert engaged in several fisheries economics efforts during the November-December period. First, he organized a one-day workshop on salmon economics on November 13, 1988, at the Pacific Fishery Management Council (PFMC) office in Portland, Oregon. Participants included James Wilen (University of California, Davis, Department of Agricultural Economics), R. Bruce Rettig and Olvar Bergland (Oregon State University, Department of Agricultural and Resource Economics), Chris Carter (Oregon Department of Fish and Wildlife), Hans Radtke and James Seger (PFMC Staff), and Richard Young (fisherman from Crescent City, California and member of PFMC's Scientific and Statistical Committee). The purpose of the workshop was to review current economic assessment methods applied to salmon fishery regulations, determine shortcomings of current methods, and describe needs for additional data and analysis for better assessments. Of special interest is the applicability of current economics assessments to the commercial-recreational allocation problem. The workshop found significant gaps in data and knowledge which makes the current information inconclusive. The workshop report describes four areas of research that could strengthen the salmon regulatory assessments.

Development of methods and information for economic assessments in fisheries is highlighted in other projects as well. Dr. Huppert has initiated a NOAA-wide project to develop standard guidelines for economic evaluations pertaining to regulations, damage assessments, and benefit-costs analyses. The resulting guidelines would serve both NOAA and outside agencies in reducing the range of controversy over economic assessments. A kick-off meeting on January 17-18, 1989, in La Jolla, to be attended by economists from NMFS and NOAA, will establish a plan for the effort, including specifications for an S-K project to be supervised by NOAA-Fisheries. (D. Huppert, FTS 893-7114)

Analysis of Effort Response in West Coast Ocean Troll Salmon Fisheries

One component of the west coast commercial fisheries assessment model being developed by Industry Economist Sam Herrick is a model of effort supply response in west coast ocean troll fisheries

for chinook and coho salmon. The regression model attempts to explain the seasonal patterns of ocean troll fishing effort in major port areas as influenced by economic, biological and regulatory circumstances. The model takes the form:

$$(E/D)_i = \exp(\alpha_0 + \sum_{j=1}^5 \alpha_j M_j) \pi_i^{[(C/E)*P]} \beta_i$$

$$(C/E)_i = \exp(\mu_0) (E/D)_i^{\tau_1} CC_i^{\tau_2} BI_i^{\tau_3}$$

where:

- E = monthly effort, in thousand deliveries, for area i
- D = monthly days of open season of both species for area i
- M = dummy variables for the months May-September
- C = combined monthly landings of chinook and coho salmon for area i
- P = weighted average monthly exvessel price for chinook and coho salmon by area
- CC = cumulative catch of both species for area i, over the months May-October
- BI = biomass index (total annual catch/total annual catch 1976)

and

- $(E/D)_i$ = effort intensity for area i
- $[(C/E)*P]_i$ = return per unit effort for area i
- $(C/E)_i$ = catch per unit effort for area i.

The model has been initially estimated using monthly catch, effort and exvessel price data for the Oregon ocean troll salmon fishery that were compiled by major port area (Figure 11). The regulatory variable, days of open season, represents the number of days out of the month that fishing can occur for either chinook, or coho salmon, or both. Days of open season during a particular month can vary across port areas. The effort intensity measure, therefore, accounts for changes in the length of the overall fishing season.

Preliminary results indicate that, as expected, monthly effort intensity in a particular area is significantly and positively influenced by the economic return to fishing effort in that area, and

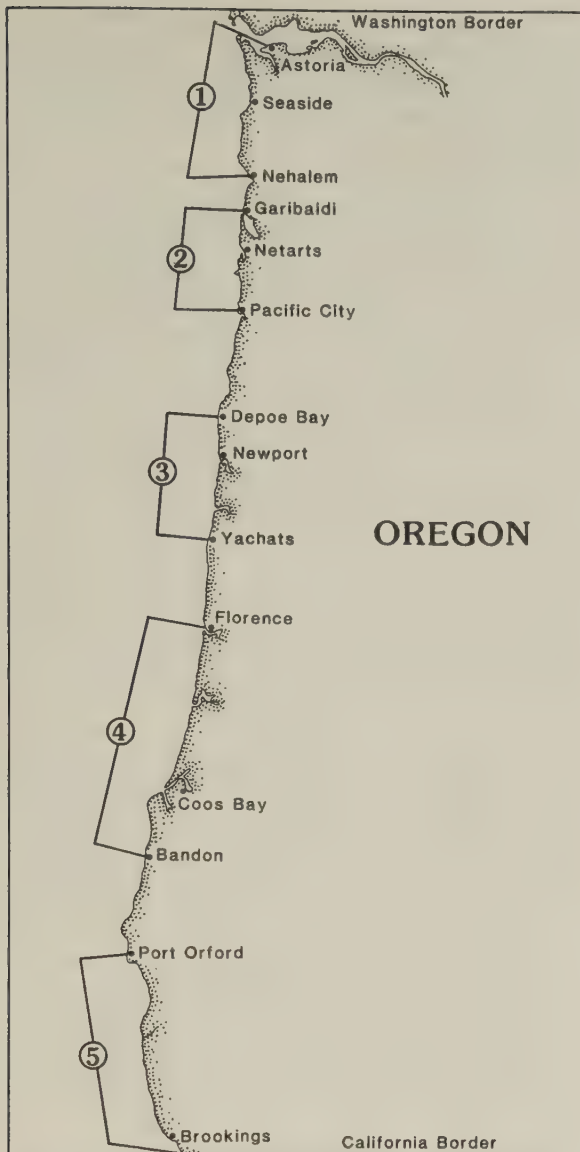


Figure 11. Major port areas for Oregon ocean troll salmon fisheries.

for the most part negatively influenced by the returns to effort in other areas. At the same time, catch per unit effort, which effects return per unit effort, is strongly influenced by effort intensity. In most cases catch per unit effort decreases with increasing effort intensity with increasing cumulative, within-season catch. As expected from theory, catch per unit effort increases as relative abundance increases.

Continuing research in this area is directed toward finding a more efficient estimator for the simultaneous system of catch per unit effort and effort intensity equations, as well as incorporating

the California ocean troll salmon fishery into the analysis. (S. Herrick, FTS 893-7111)

Preparation of Course in Ocean Resources

Dr. Dale Squires, Industry Economist, has primarily been preparing a course to be taught during the winter 1989 quarter at the University of California, San Diego. The course is entitled, "The Economics of Ocean Resources." This undergraduate course first develops the theory and management concepts of natural resource economics as applied to the usage of ocean resources. The course next applies these concepts to a wide range of ocean resources, including: fisheries; transportation, navigation, and ports; petroleum and natural gas; alternative energy sources; minerals; piracy; pollution and waste disposal; aquaculture; and a number of issues pertinent to the Pacific Rim countries. The course features a number of guest speakers, including from the Southwest Fisheries Center: Dr. Daniel Huppert on fisheries management; Dr. Samuel Herrick, Jr. on the tuna industry; and Dr. Douglas DeMaster on marine mammal management. Additional guest speakers will discuss aquaculture business and the San Diego port. (D. Squires, FTS 893-7113)

Statistical Tests for Recreational Fisheries Models

Cynthia Thomson, Industry Economist, is evaluating the usefulness of various statistical procedures for evaluating the types of model specifications found in the recreational demand literature. Most of the commonly used procedures for testing nested hypotheses (e.g., F-tests) and non-nested hypotheses (e.g., Wald or likelihood ratio tests associated with embedding rival models into a general model) tend to exhibit low power, due to the frequent presence of multicollinearity in economic data. Tests of non-nested hypotheses based on the use of *ad hoc* selection criteria such as maximum adjusted r^2 are also frequently used. One criticism of such criteria is that they require one of the models being considered be the "true model"-- an assumption which is not likely to be satisfied in practice.

A test procedure which does not possess the deficiencies of the commonly used procedures described above was devised by Cox. Cox's test statistic is based on a modification of the

Neyman- Pearson likelihood ratio and is applicable to testing non-nested hypotheses in situations where the data are collinear. However, the Cox test can be inconclusive in the sense that it can result in rejection or non-rejection of both models being considered.

Thomson is also examining a relatively new concept in statistical test procedures known as the "encompassing principle." According to this principle a key feature of the true model of any given phenomenon is that it is able to account for, or "encompass", the behavior of all empirical models of the same phenomenon. In reality, this true model is never known to the analyst. However, an empirical model which encompasses other empirical models can be said to be "better" than its rivals in the sense that it mimics this important behavioral characteristic of the true model. Mizon has devised a test statistic based on this encompassing criterion.

Thomson is attempting to illustrate the usefulness of the Cox and encompassing tests using models and data associated with the Bay Area Sportfish Economic Survey. (C. Thomson, FTS 893-7115)

FISHERY-MARINE MAMMAL INTERACTIONS DIVISION

La Jolla, California

BIOLOGY ASSESSMENT PROGRAM

Harbor Porpoise Working Group of the European Cetacean Society

From November 29 through December 1, the Harbor Porpoise Working Group of the European Cetacean Society sponsored a workshop on the biology of harbor porpoise at the Sea Mammals Research Unit, British Antarctic Survey (BAS) in Cambridge, England. The workshop was primarily aimed at standardizing the examination, sampling and sample analysis of porpoise and facilitating the examination of samples from many countries by specialists in particular areas of research. Specifically, practical sessions included dissection of two porpoise, including methods for taking morphometrics, and laboratory sessions for age estimation and sectioning of ovaries. Discussions during

the workshop focused on minimum data collection requirements, intraspecific variation for stock discrimination, age estimation, reproduction, pollution, energetics, parasites and pathology, and surveys.

The 30 participants at the workshop represented 12 countries. Three scientists from the Southwest Fisheries Center attended. Fishery Biologist Aleta A. Hohn was invited to attend to discuss estimation of age in harbor porpoise by chairing a session and helping with a laboratory demonstration on this topic. She also assisted in the reproduction session, serving as rapporteur. Jay Barlow, Operations Research Analyst, acted as rapporteur for the session on pollutants and discussed surveys for porpoise along the California coast. Christina Lockyer, a visiting scientist at the SWFC for 18 months from BAS' Sea Mammals Research Unit, returned to Cambridge for the Workshop. She chaired sessions on reproduction and energetics and was rapporteur for the session on age estimation.

A report summarizing the main points of the workshop is being prepared. There is considerable value in having standardized techniques for data and sample collection, especially when many people from so many countries are working on the same issues towards similar goals. Probably equally as valuable was getting those people together and interacting so that they know one another. It also provides them with contacts with expertise in specific research areas outside their own specialties. (A. Hohn, FTS 893-7088)

FISHERY INDEPENDENT ASSESSMENT PROGRAM

Aerial Photographs Taken to Calibrate School Size Estimates

For the second year, aerial photographs were taken during the dolphin surveys to calibrate observers' estimates of dolphin school size. Typically it is very difficult to estimate the size of dolphin schools from a ship, especially when some schools include several thousand individuals. It is not known whether dolphin observers are making large, systematic errors when estimating dolphin school size. Such errors would appear directly as biases in the estimation of dolphin abundance. To resolve the question of bias, a helicopter and an aerial photography

program were incorporated into the design of the dolphin survey. The helicopter operates from a specially-constructed platform on the NOAA Ship *David Starr Jordan*. Two high-resolution aerial reconnaissance cameras hang underneath the helicopter and are used to take large-format photographs of a sample of dolphin schools. From these photographs, the actual number of dolphins in a school can be counted, and individual observers can be calibrated against this more precise estimate of school size. The survey design calls for a transfer of dolphin observers between the two survey vessels between Legs 2 and 3. This transfer allows all 12 observers to be calibrated.

Four members of the SWFC photogrammetry program participated in this year's survey. Team members included Jay Barlow (Leg 1), Morgan Lynn (Legs 1, 2, and 4), James Gilpatrick (Legs 2 and 3), and Mark Lowry (Legs 3 and 4). In addition to the two photogrammetrists present on each leg, the aerial team consisted of a pilot and a helicopter mechanic, both provided by the NOAA Office of Aircraft Operations. This year, the pilots included David Gardiner (Leg 1), Bud Chrisman (Leg 2), and Bill Hines (Legs 3 and 4), and the mechanics included Carl Anderson (Legs 1 and 3) and John Crona (Legs 2 and 4).

Table 1. Number of schools of small cetaceans photographed during dolphin surveys in 1987 and 1988. The number of helicopter hours is given in parentheses.

	Leg 1	Leg 2	Leg 3	Leg 4	Totals
1987	24 (36 hr)	38 (28 hr)	28 (47 hr)	24 (47 hr)	114 (158 hr)
1988	8 (11 hr)	20 (34 hr)	25 (46 hr)	18 (43 hr)	71 (134 hr)

During flight operations one member of the photogrammetry team sat in the front seat operating the cameras and directing the pilot. The second team member sat in the back seat and recorded important information pertaining to each photographic pass. This year, a computer data recording system was added to improve the quality of information that accompanies each photograph. The computer software, written by Jim Cabbage of Cascadia Research Collective, not only speeds note-taking but also automatically records the time and altitude whenever one of the cameras is fired.

The cameras are typically fired at a rate of several frames per second, much faster than a person can record. Being able to count each frame helps to assign a given photograph to a specific photographic pass on a specific school. Having an altitude for each frame will improve the accuracy with which dolphin lengths can be measured from the photographs.

This year's efforts were plagued with several equipment malfunctions and worse-than-average weather. The equipment malfunctions were all related to failures of the camera control boxes. These elaborate electronic devices cue the cameras to fire at a rate that is specific for a particular speed and altitude. The primary control box failed just prior to the start of the cruise. The second box showed intermittent problems during Leg 1 and failed completely during Leg 2 of the cruise. Fortunately, a third back-up control box functioned until the end of Leg 3, and the primary box was fixed and shipped to Manzanillo in time for Leg 4. Problems caused by poor weather could not be resolved as easily. In order to see submerged dolphins in aerial photographs, the sea surface must be relatively calm, and there must be sufficient direct sunlight. Because of overcast and rough seas, fewer schools were photographed this year compared to last year. It is expected, however, that photographic quality will be better this year, and thus a higher fraction of those schools that were photographed will be useful for estimating school size. The number of schools photographed during each of the four legs of the cruise are given in Table 1 for 1987 and 1988. Researchers in the photogrammetry program are currently examining all photographs taken during the 1988 survey and are deciding which are of adequate quality to estimate school size. (J. Barlow, FTS 893-7178).

Dolphin Stock Assessment Program MOPS 88 Cruises Completed

Two NOAA Ships, the *David Starr Jordan* and the *McArthur*, departed San Diego on July 28 to conduct research in the eastern tropical Pacific. The *Jordan* was equipped with a Hughes 500D helicopter. The primary objective of the survey was to collect information to estimate the density, size, and species composition of dolphin schools in the eastern tropical Pacific (ETP) Ocean. Of special interest are the spotted, spinner, common, striped and Fraser's dolphin. Populations of these five species, herein grouped and termed

target species, are impacted by tuna purse seining in the ETP. The second objective was to collect information to investigate the physical and biological environment of the dolphin schools sighted. The vessels returned to San Diego early December 6. The *McArthur*, based out of Seattle, departed San Diego for home on December 8. Results presented here include preliminary summaries of data describing cetacean sightings during the survey. (Discussions of the environmental data collected and helicopter operations are presented elsewhere in this issue of the Report of Activities.)

The vessels surveyed along predetermined tracklines and made three port calls each during the 4 month survey. The tracklines are designed for line transect applications and distribution of effort between regions was calculated using density estimates from earlier surveys. The actual tracklines of the vessels are shown in Figure 1. The *Jordan* and the *McArthur* surveyed 19,446 nm and 20,698 nm, respectively, in the study area. Within the study area, 42% of the effort was in the inshore region, 23% middle, 17% west, and 18% in the southern regions, respectively. The *Jordan* had port calls in Guatemala, Panama and Mexico. The *McArthur* had port calls in Hawaii, Panama and Peru.

The cetacean survey was conducted by maintaining a visual watch using two 25-power binoculars mounted on the port and starboard sides of the flying bridge of each vessel. Binoculars were mounted on pedestals at a height of 10 m above the water, giving a maximum ship-to-horizon sighting distance of approximately 10 km. Daily watch for marine mammals was maintained during daylight

hours (approximately 0600 to 1800 hrs local). Watch was stood by two teams of three observers on each vessel (6 observers per vessel), with each team rotating every 2 hours.

On sighting a marine mammal school, information describing the sighting was recorded (e.g., time and position of the vessel, sighting cue and bearing and distance to the cue, and values of environmental parameters at the time of sighting). The bearing from the vessel to the sighted school was read from an azimuth ring on the binocular mount. Distance to the sighted school was recorded as a reticle distance read from a reticle mounted in the binocular eyepiece. When necessary for species identification confirmation, 35 mm photographs of the school were taken and noted in a log.

Simultaneously, the CAST (Computer Assisted Sighting Technology) system continuously recorded bearing information. The CAST system was developed to more precisely measure the bearing to a sighted school and also to then use these bearing data to estimate initial distance to the school. CAST records the binocular bearing using a shaft encoder housed within the binocular mounts. The bearing is then converted into a compass direction using information from the ship's gyrocompass and corrects this direction for vessel pitch and roll using information from a sensor. To calculate an initial distance estimate, CAST needs to collect approximately 18 minutes of bearing information, during which the vessel maneuvers and eventually approaches the school. If sighting and environmental conditions of the sighting allowed sufficient data to be collected, distance was also calculated by CAST. Data collected from the CAST system on this and previous cruises will be analysed for reliability.

Preliminary calculations indicate that 1,027 schools of marine mammals were sighted. Despite the *McArthur* surveying in rougher conditions, total sightings for both vessels were similar (492 schools on the *McArthur* vs. 535 on the *Jordan*). Of total schools detected from both vessels, 32% were seen on Leg 1, 32% on Leg 2, 18% on Leg 3, and 18% on Leg 4. Thirty-nine percent of all schools sighted (398 schools) contained target dolphins. Preliminary results of sightings by species for both vessels combined are presented in Table 2.

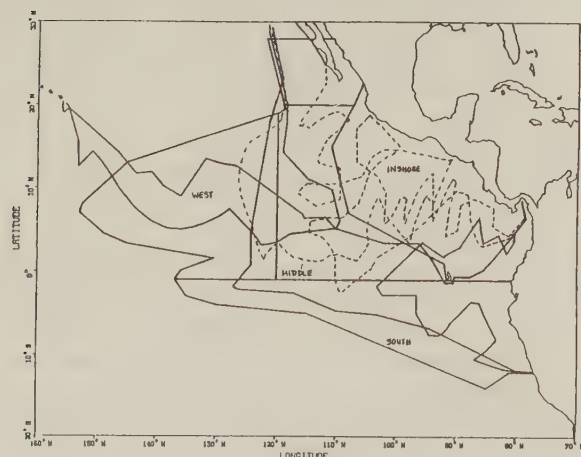


Figure 1. Tracklines for the 1988 MOPS surveys in the eastern Pacific using the NOAA Ships *McArthur* (solid lines) and *David Starr Jordan* (dashed lines).

Table 2. Preliminary results of cetacean sightings from the NOAA/NMFS/SWFC 1988 eastern tropical Pacific dolphin survey.

	Leg 1	Leg 2	Leg 3	Leg 4	Total
Spotted dolphin	28	22	25	38	113
Spinner dolphin	24	19	18	25	86
Common dolphin	5	7	41	19	72
Striped dolphin	40	45	83	37	205
Rough-toothed dolphin	7	3	5	28	43
Bottlenose dolphin	10	4	23	26	63
Risso's dolphin	2	4	13	24	43
Fraser's dolphin	3	2	—	1	6
Dusky dolphin	—	—	—	1	1
Pacific whitesided dolphin	—	—	—	5	5
Unidentified dolphin	55	44	46	50	195
Melon headed whale	—	1	1	1	3
Pygmy killer whale	1	1	1	4	7
False killer whale	2	1	—	1	4
Pilot whale	8	14	22	11	55
Killer whale	3	4	—	4	11
Sperm whale	5	4	9	15	33
Dwarf sperm whale	4	6	4	7	21
Beaked whale	—	7	24	17	48
Mesoploden whale	2	4	11	9	26
Rorqual whale	4	4	1	15	24
Bryde's whale	2	2	5	7	16
Bue whale	2	—	3	1	6
Humpback whale	—	—	1	5	6
Minke whale	—	—	—	3	3
Unidentified small whale	7	6	4	5	22
Unidentified large whale	8	4	7	5	24
Unidentified whale	12	14	12	12	50
Unidentified cetacean	5	3	10	10	28

(S. Sexton, FTS 893-7097)

FISHERY DEPENDENT ASSESSMENT PROGRAM

1988 MOPS Environmental Data Collection Completed

The return of the NOAA Ships *McArthur* and *David Starr Jordan* to San Diego on December 6 marked the conclusion of a successful field season for Fishery Biologist Dr. Steve Reilly's (SWFC) program of dolphin habitat assessment in the eastern tropical Pacific. 1988 was the third year of the 6-year Monitoring of Porpoise Stocks program.

Environmental data are collected for studies of stock distribution and for interpretation of inter-annual changes in abundance estimates. The oceanographic variables measured are temperature, salinity, chlorophyll, dissolved oxygen, and nutrients (nitrate, nitrite, phosphate, and silicate). We also recorded 38 kHz acoustic backscatter profiles, censused pelagic seabirds, and collected neuston, flying fish, and fish stomachs. Table 3 summarizes the 1988 sampling effort.

Several changes were made this year to improve the quality and efficiency of data acquisi-

Table 3. Summary of environmental data collected on the NOAA Ships McArthur and David Starr Jordan during the 1988 MOPS cruises, July 28-December 6.

	Jordan	McArthur
XBT's	411	424
CTD stations	168	183
Chlorophyll samples	1770	1843
Nutrient samples	1844	2007
Manta tows	82	69
Flying fish collected	975	102
Fish stomachs sampled	255	238
Turtle sightings	99	66
Bird sightings	17,100	10,047

Surface temperature, salinity, and fluorescence measured continuously on both ships. Acoustic backscatter measured continuously on the *Jordan*.

tion. Software written by Computer Specialist Robert Holland was used to sample and record surface temperature, salinity, and fluorescence signals with PC's. The software was also used in blanking and calibrating the flow-through fluorometer to improve the accuracy of surface chlorophyll estimates. A thermosalinograph was installed on the *McArthur* just 2 days prior to departure on July 28, thanks to Captain Gerald Stanley and our retiring port captain Lloyd Farrar. Operations Research Analyst Dr. Jay Barlow (SWFC) reconfigured his Acoustic Data Acquisition System on the *Jordan* to record returns from the water column down to 500 m, allowing us to monitor the deep scattering layer both day and night.

Analysis and processing of this year's data will continue over the next few months. From our own data and other sources, we already know that, at least oceanographically, 1988 was very different than 1986 and 1987. A moderate El Niño in 1986-1987 was comparable to the 1972 and 1977 events: sea surface temperature 1-2°C warmer than normal, a deep thermocline, weak trade winds, and weak zonal surface currents were observed in the eastern and central equatorial Pacific. In contrast, 1988 saw surface temperatures 1-2°C colder than normal, a shallow thermocline, and unusually strong winds and surface currents. We expect these changes to have affected nutrient availability, phytoplankton abundance and, ultimately, the abundance and distribution of forage organisms.

Many people contributed to the success of this year's effort. Oceanographic data were collected by Survey Technicians Julie Ellingson and Seth

Strickland (PMC) on the *McArthur* and by Oceanographers Lisa Lierheimer (SWFC), Gregg Thomas (Atlantic Oceanographic and Meteorological Laboratory), and Dr. Paul Fiedler (SWFC) on the *Jordan*. Bird observations and manta net tows were conducted by Lisa Ballance (SWFC), Bob Pitman (SWFC), Karen Bluth, John Gill, James Gilardi, James Caretta, and Michelle Roest. Dip-netting was conducted by Pitman, Rick LeDuc and Keith Rittmaster. Fish stomachs were sampled by Pitman and Vicky Thayer. (P. Fiedler, FTS 893-7016).

COASTAL MARINE MAMMAL PROGRAM

Survivorship Patterns in Seven Species of Captive Pinnipeds

DeMaster and Drevenak (1988) reported on rates of survival for three species of captive cetaceans. These estimates were based on information provided to the National Marine Fisheries Service by various oceanaria and zoological parks as part of the requirements for obtaining permits to capture or transfer marine mammal species for public display. Estimates of survival for bottlenose dolphins, killer whales and white whales, when pooled over all reporting institutions, were similar. However, significant differences in rates of survival for bottlenose dolphins between institutions and by age were reported. In addition, for killer whales, survival rate of males was significantly less than the survival rate of females. Because of these age-, sex- and institution-specific differences in annual survival, DeMaster and Drevenak recommended that any evaluation of an institution's husbandry practices consider these confounding factors. The primary objective of this study was to estimate the post-capture survival for seven species of pinnipeds (California sea lion, *Zalophus californianus*, northern sea lion, *Eumatopius jubatus*, northern fur seal, *Calorhinus ursinus*, New Zealand fur seal, *Arctocephalus forsteri*, South American fur seal, *A. australis*, South African fur seal, *A. pusillus*, harbor seal, *Phoca vitulina*). These estimates may be useful in identifying institutions that either are superior or inferior in maintaining pinnipeds in captivity. A report presenting the results of this analysis has been completed by Dr. Douglas P. DeMaster, Eric Dorfman, Tracy Jo Richter, and Mark Wimer. The following methodology was used in estimating the annual

survival rate and in comparing survival rates by categories of institution, age, sex, and date:

$$DSR = \frac{\sum_{i=1}^K Y(i)}{\sum_{i=1}^K X(i)}$$

$$ASR = DSR^{365.25},$$

where DSR is the daily survival rate, ASR is the annual survival rate, Y(i) is one if the ith individual died during the reporting period and zero if the ith individual survived through the entire reporting period, X(i) is the total number of days, including any days in which deaths may have occurred, in the reporting period for the ith individual, and K is the number of animals in the sample.

The preliminary results are presented in Table 4. Except for northern fur seals, survival for the species of pinnipeds reported here was comparable to the survival of the three species of cetaceans reported by DeMaster and Drevenak (1988). Survival rates were generally between 0.94 and 0.96.

Table 4. Summary of survival rates for seven species of pinnipeds. The dates over which the data were collected are given under the common name of each species. The 95% confidence interval for each species is given in parenthesis under the survival rate.

Species	Animals held	Survival rate
California sea lion 1942-1987	1536	0.935 (0.930-0.941)
Northern sea lion 1961-1988	39	0.96 (0.93-0.98)
Northern fur seal 1964-1988	57	0.88 (0.85-0.92)
South American fur seal 1970-1988	19	0.97 (0.94-1.00)
New Zealand fur seal 1973-1988	25	0.96 (0.93-0.99)
South African fur seal 1967-1988	44	0.95 (0.92-0.97)
Harbor seal 1944-1988	581	0.944 (0.936-0.953)

For California sea lions, there was no significant difference between the annual survival of males and females. The annual survival rate of California sea lion pups that were born in captivity was 0.82. (D. DeMaster, FTS 893-7165).

HONOLULU LABORATORY

Honolulu, Hawaii

Townsend Cromwell Has 25th Birthday

The 25th birthday of the NOAA Ship *Townsend Cromwell* was celebrated December 1, 1988, with an open house aboard the vessel. The 164-foot-long *Townsend Cromwell* acts as the primary research platform for the Honolulu Laboratory and also provides transportation for scientists to remote locations throughout the Pacific. Operated by the Pacific Marine Center, National Ocean Service, NOAA, the *Townsend Cromwell* is staffed by NOAA officers under the command of LCDR Robert J. Pawlowski.

Use of the *Townsend Cromwell* allows Honolulu Laboratory scientists to conduct such research as assessing insular fishes, shrimps, and lobsters; studying the recruitment and recovery of fishery resources on the Hancock Seamounts; assessing stocks and studying the life histories of various tunas; collecting larvae and juvenile pelagic fishes; and conducting research and recovery work on the threatened Hawaiian green turtle and endangered Hawaiian monk seal. Not surprising, the *Cromwell* spends as much as 250 days per year away from Honolulu.

The *Townsend Cromwell* was designed by George C. Nickum and Sons of Seattle, Washington, and built by the McDermott Company at Morgan City, Louisiana. It is 33 feet in beam, draws 11 feet, and displaces 565 tons. With a top speed of 12 knots and cruising speed of 10.5 knots, the *Cromwell* has a cruising range of 10,000 miles on 41,000 gallons of fuel. It can carry enough food and water for 17 officers and crew members and 9 scientists for 30 days at sea. It was launched July 27, 1963, arriving at Honolulu on Christmas Day. Total cost of the vessel was \$1.7 million.

The vessel was named for Townsend Cromwell, a brilliant oceanographer who is perhaps

best known for discovering the equatorial under-current to which his name has been given. From 1949 to 1953, Cromwell was an oceanographer at the Pacific Ocean Fishery Investigations (now the Honolulu Laboratory) and, at the time of his death in 1958, was a senior scientist with the Inter-American Tropical Tuna Commission and research associate at the Scripps Institution of Oceanography (Figure 1).



Figure 1. LCDR Robert J. Pawlowski (left) presents Honolulu Laboratory Director Dr. George W. Boehlert (right) with the original compass binnacle from the NOAA Ship *Townsend Cromwell*, for placement at the Laboratory.

INSULAR RESOURCES INVESTIGATION

Prawns Assessed in the Gulf of Papua

Assessment of the prawn trawl fishery in the Gulf of Papua was recently completed by Jeffrey J. Polovina, Investigation Chief with the Honolulu Laboratory, and Joel Opnai, Biologist with the Department of Fisheries and Marine Resources in Papua, New Guinea. The fishery, which began in 1969, has an annual harvest valued in excess of \$10 million, making it the country's most valuable fishery, after tunas. A surplus production model fit to annual catch and effort data from 1974 to 1987 estimated annual maximum sustainable yield (MSY) for the multispecies prawn fishery at 1,538 metric tons (t) and MSY for the principal and most

valuable species, the banana prawn, *Penaeus merguensis*, at 575 t (Figure 2).

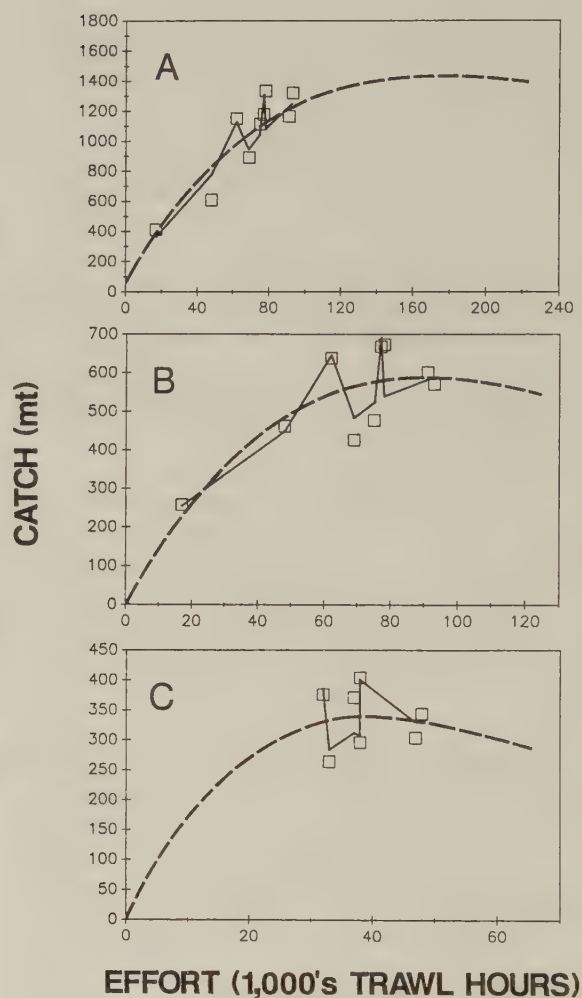


Figure 2. Exponential surplus production model with only effort as the independent variable (---) and an exponential surplus production model with both minimum rainfall during September- November and effort as independent variables (—) fit to three data sets: (A) all prawns, (B) banana prawns, (C) Kerema Bay banana prawns.

Time series analysis used ARIMA models to remove autocorrelations from the prawn catch-per-unit-effort (CPUE) and rainfall series, then cross correlations were computed between the transformed prawn and rainfall series. The cross correlations suggested an inverse relationship between rainfall in November (when the prawns settle in the mangroves) and prawn CPUE 5 months later. The surplus production model, which was modified by adding a minimum rainfall variable, explained substantially more of the

variation in catch than did the effort-only production model (Figure 2).

The inverse relationship between rainfall and prawn CPUE is exactly the opposite of that found in the Australian prawn fishery in the Gulf of Carpentaria. In the Australian fishery, high rainfall triggers the migration of prawns from the nursery to the fishery. However, the Gulf of Carpentaria has only about 900 mm of rainfall annually, and the Gulf of Papua, 2,700 mm. Thus, the Gulf of Papua is hypothesized as having more than enough rainfall to trigger movement of prawns from the nursery grounds.

Although the biological significance of the inverse relationship between rainfall in November and prawn CPUE in the next calendar year is not known, it may indicate that if rainfall is high when prawns are settling or newly settled, many of the prawns are washed prematurely from the nursery grounds and suffer high mortality, whereas low rainfall during settlement results in high postlarval survival and, subsequently, above average recruitment to the fishery. (J. Polovina (808) 943-1218)

PELAGIC RESOURCES INVESTIGATION

Swimming Depth and Deep Muscle Temperature Telemetry Data on Tuna Reveal Remarkable Thermoregulatory Ability

The tuna tracking project, jointly sponsored by the National Marine Fisheries Service (NMFS), University of Hawaii (UH) Sea Grant Program, and State of Hawaii, was expanded this past summer to include experiments in which both deep muscle temperature and swimming depth of bigeye tuna, *Thunnus obesus*, and yellowfin tuna, *T. albacares*, are telemetered by attaching two ultrasonic transmitters to a single fish. The work was conducted aboard the NMFS research vessel *Kahele'ale* off Kailua-Kona, Island of Hawaii, by Fishery Biologist Richard W. Brill with the Honolulu Laboratory, NOAA Corps Officer Ltjg Mark Ablondi, Kim Holland with the UH, Hawaii Institute of Marine Biology, and Bob Harmon with the State of Hawaii. The overall objective of the work is to determine movement patterns and rates of energy expenditure of tunas when they are associated with fish aggregating devices and when they are not.

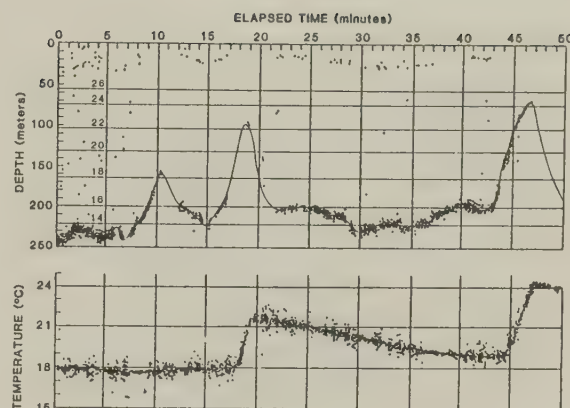


Figure 3. Swimming depth and deep muscle temperature record of a bigeye tuna tracked in the fall of 1988 off Kailua-Kona, Hawaii. Swimming depth is in the upper panel. The 2°C isotherms, determined with expendable bathythermographs, have been added to the upper panel. The lower panel shows the simultaneously recorded deep muscle temperature.

Previous telemetry studies by Brill and Holland have shown that during daylight hours, bigeye tuna occupy waters of about 15°C but make regular excursions (every 45 to 60 minutes) up to the 25°C water. It is hypothesized that these upward movements allow the fish to warm its muscles. In other words, the fish, during ascent, reduces the efficacy of its vascular countercurrent heat exchangers to take up heat from the surrounding water as rapidly as possible, then, during descent, increases its efficacy to slow the rate of cooling (i.e., minimize the rate of heat lost to the environment). The data, in Figure 3, from tracking a bigeye tuna clearly shows that this is the case. When the fish's deep muscle temperature reaches 18°C, it begins its ascent, warms rapidly, then returns to the 15°C water and cools very slowly. Data from this bigeye tuna and six other bigeye and yellowfin tunas tracked this summer are undergoing further analysis. (R. Brill (808) 943-1234)

FISHERY MANAGEMENT RESEARCH PROGRAM

American Samoa Tuna Sampling Reports Are Completed

Two recently released Administrative Reports on the NMFS tuna sampling program in American Samoa have been widely circulated to

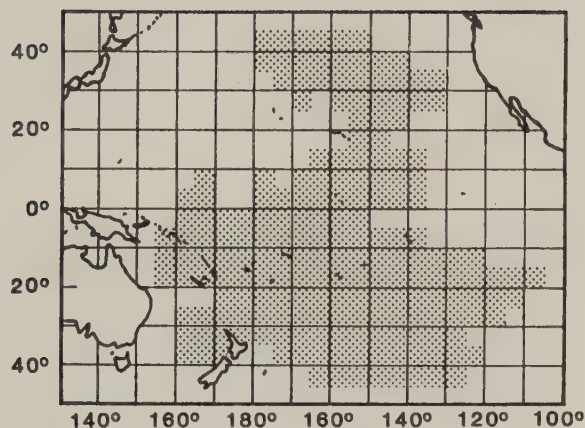


Figure 4. Area fished by longliners operating out of American Samoa, 1982-86.

the tuna industry: "Status of American Samoa foreign longline tuna fishery, 1982-86" (H-88-19) by Russell Y. Ito and Gordon S. Yamasaki and "American Samoa purse seine fishery sampling" (H-88-20) by Victor A. Honda, Gordon S. Yamasaki, and Russell Y. Ito. The longline and purse seine reports give the history and methods of the NMFS sampling program in American Samoa and also present information on the current status of the fisheries. The tuna sampling program was conducted by the Honolulu Laboratory from 1962 through 1987; it is now conducted by the Southwest Region. A brief summary report on the 1987 fishery will be compiled shortly.

Once made up entirely of vessels from Japan, the longline fleet of almost 200 vessels off-loading at the tuna canneries in Pago Pago has, in recent years, been composed almost entirely of vessels from Taiwan and South Korea. Total landings are estimated at 20,000-25,000 metric

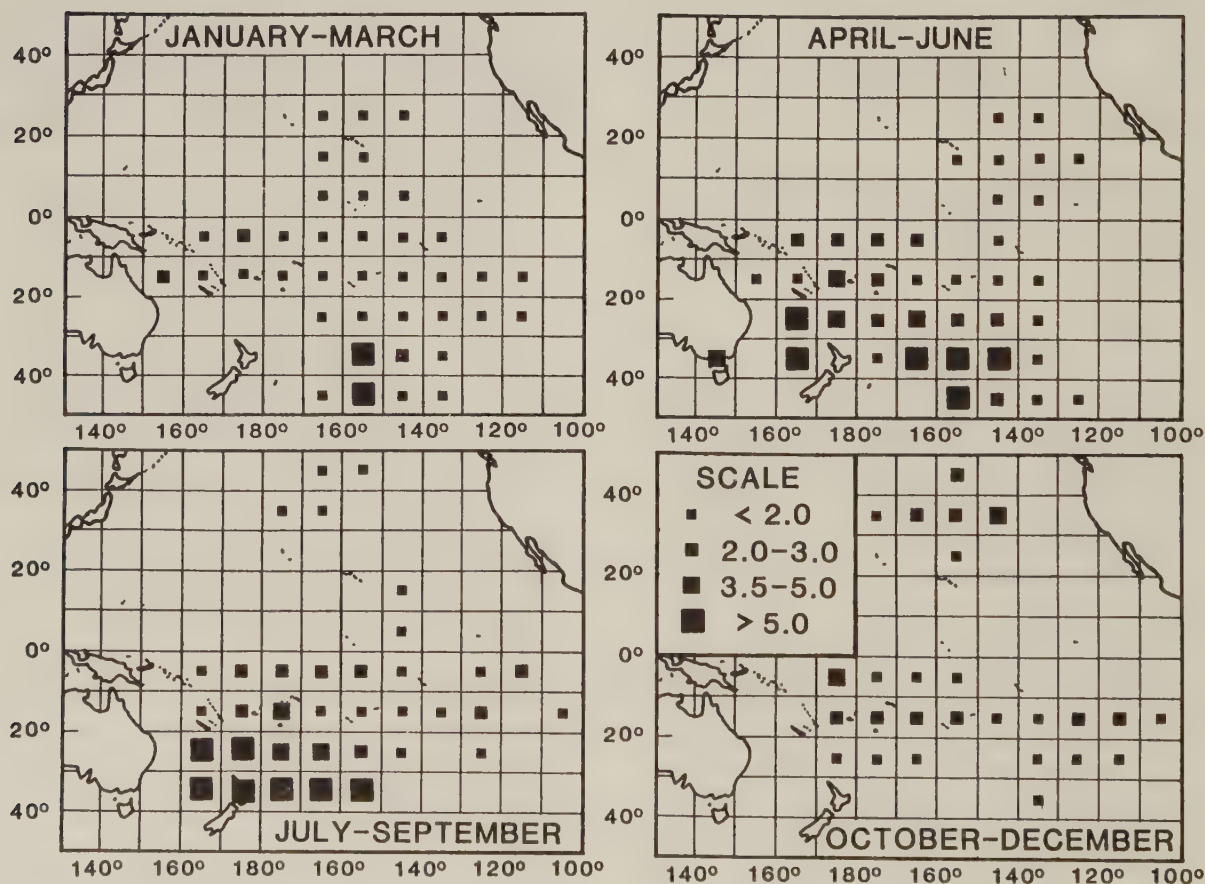


Figure 5. Geographic distribution of albacore catch-per-unit-effort in 3-month intervals, 1986. Catch symbols in a land-bordered 5° square do not necessarily reflect fishing effort within exclusive economic zones.

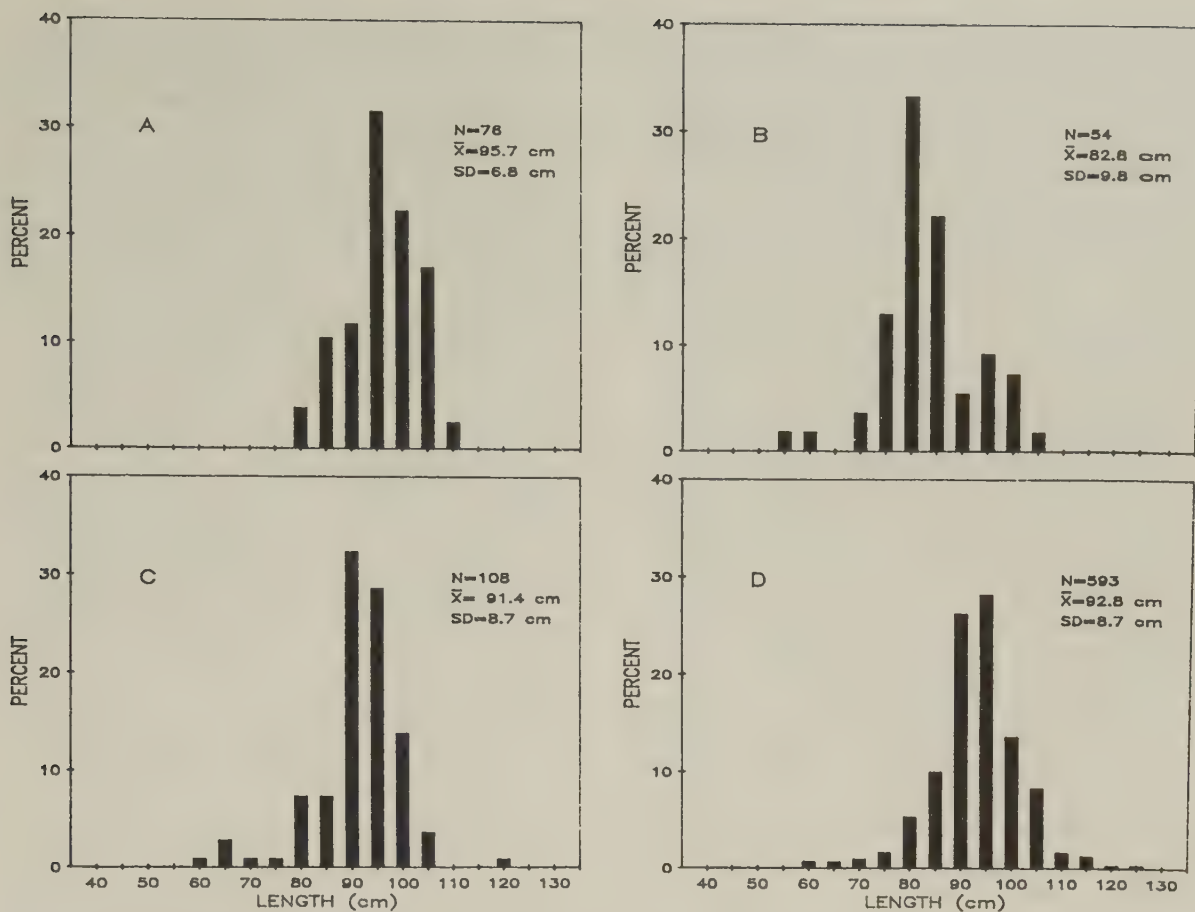


Figure 6. Length frequency of longline-caught albacore in (A) January-March, (B) April-June, (C) July-September, and (D) October-December 1986.

tons; albacore, *Thunnus alalunga*, constitute the vast majority (80%) of the landings. The report also indicates the geographical range of the fishery (Figure 4), the distribution of catch-per-unit-effort (Figure 5), and the size composition of the albacore catch (Figure 6). Unfortunately, errata crept into the maps of this report, because a Mercator projection was overlaid across the computer digitized mapping of fishing locations, thus making land masses north of the Equator appear farther south and those south of the Equator appear farther north.

The purse seine report indicates that 30 purse seiners off-loaded in Pago Pago in 1986. Skipjack tuna, *Katsuwonus pelamis*, comprised 69% of the landings; yellowfin tuna, *Thunnus albacares*, and bigeye tuna, *T. obesus*, comprised only 30%. The landings sampled are from U.S. vessels only, therefore, much of the quantitative information on the fishery is confidential. Most of the quantitative

information in the report involves the size composition of the landings. (R. Ito (808) 943-1210)

Update on Hawaii's Lobster Fishery

Through the third quarter of 1988, activity of the lobster fishery in the Northwestern Hawaiian Islands (NWHI) has remained relatively unchanged from 1987 in terms of trips taken and vessels fishing; however, landings have increased substantially for spiny lobster, *Panulirus marginatus*, and declined substantially for slipper lobster, *Scyllarides squammosus*, according to Fishery Biologist Raymond P. Clarke. Landings through September 1988 equaled 617,375 spiny lobster and 239,085 slipper lobster taken by 9 different fishing vessels on 19 trips. Catch-per-unit-effort (CPUE) for spiny lobster was almost twice that in 1987, while the CPUE for slipper lobster was down.

Fishing reportedly was "good to excellent" during the summer. Combined with relatively good wind and sea conditions, production was the best in at least 2 years, according to the fishermen. The catch rates for spiny lobster were the highest since 1985.

The ex-vessel price of spiny lobster fell to \$10.63/lb (frozen tails), compared with the 1987 average of \$13.06/lb. Slipper lobster prices also declined but less so. Total revenue through September 1988 was an estimated \$3.6 million.

For the first time in the relatively brief history of the NWHI lobster fishery, several vessels have ceased lobster fishing late in the year and are converting to tuna longline fishing. The vessel owners indicate they will return to lobster fishing in the spring of 1989. (R. Clarke (808) 943-1213)

Council's Advisory Board Reviews Bottom Fish Report

The first meeting of the Western Pacific Regional Fishery Management Council's (Council's) Bottomfish Advisory Review Board was held November 10th at the Honolulu Laboratory. The purpose of the Board is to make recommendations to the Council concerning entry and vessel replacement in the limited entry (Ho'omaluku) zone in the Northwestern Hawaiian Islands (NWHI) bottom fish fishery. During its meeting the Board reviewed a report by Biological Technician Kurt E. Kawamoto and Industry Economist Samuel G. Pooley on the current status of the NWHI bottom fish fishery. The report indicates landings and trips are down significantly in 1988, and the proportions of high-valued opakapaka, *Pristipomoides filamentosus*, and onaga, *Etelis coruscans*, in the landings have declined. Only 12 vessels have been active in 1988, compared with 28 in 1987.

The Board consists of four fishermen, one seafood market dealer, two State of Hawaii representatives, and two representatives of the NMFS. John Young, owner and captain of the fishing vessel *Sailfisher* was appointed chairperson. The NMFS representatives are Pooley and Peter A. Milone, Resource Management Specialist with the Pacific Area Office. (S. Pooley (808) 943-1216)

Hawaii Task Force on Tourism and Ocean Resources

Industry Economist Samuel G. Pooley facilitated a 2-day workshop on October 17-18 for the State of Hawaii Governor's "Task Force on Ocean

Resources Tourism Development." The purpose of the task force is to preserve, protect, and enhance the coastal and nearshore environment for ocean recreation and tourism. Workshop participants included 7 task force members and 12 resource and user group technical committee members. The workshop developed priorities on 52 major issues and 48 major activities. The material will be synthesized by the Ocean Resources Branch of the Hawaii Department of Business and Economic Development for submission to Hawaii's Governor and Legislature.

The NMFS was asked to facilitate the workshop because of its experience in interactive strategic planning and general knowledge of the subject matter. Computer Programmer Ann C. Todoki assisted in the interpretive structural modeling portion of the workshop. (S. Pooley (808) 943-1216)

Council Meets

A meeting by the Western Pacific Regional Fishery Management Council (Council) on November 27-29 in Honolulu included approval of recommendations from the annual report on the bottom fish fishery, presentation of a draft of the annual report on the pelagic fisheries, approval of another experimental fishing permit for the precious coral fishery, and approval of the Council's programmatic package. Noteworthy was the Council's support for a proposal by the Hawaii Division of Aquatic Resources to the Hawaii Legislature for a 3-lb size limit for various snappers. (S. Pooley (808) 943-1216)

Bottom Fish Logbook Data Are Reviewed

A review of the first data provided under the Western Pacific Regional Fishery Management Council's (Council's) voluntary logbook system for the bottom fish fishery in the Northwestern Hawaiian Islands has been completed by Biological Technician Kurt Kawamoto. Kawamoto found substantial positive and negative variance between the NMFS shoreside monitoring data and the logbook data; he proposed modifications to the logbooks and procedural changes for filling them out, which may improve the data. His report will be submitted to the Council's Bottomfish Plan Monitoring Team. (K. Kawamoto (808) 943-1210)

Upgrading WPACFIN Computer Processing Environment Is Planned

The Western Pacific Fishery Information Network (WPACFIN) is the backbone of fishery data and information exchange in the western Pacific. Participating entities include the principal federal and state fishery agencies in Hawaii, American Samoa, Guam, and the Commonwealth of the Northern Mariana Islands, as well as secondary participating fishery offices in Palau, Yap, Kosrae, Truk, and Pohnpei. Under the direction of the Southwest Fisheries Center, the network, initiated over 7 years ago, has grown into a comprehensive and valuable source of fishery information which is used extensively for fishery management. Fishery Management Plans for the bottom fish and pelagic fisheries identify WPACFIN as the principal source of information for managing these fisheries. With growth has come the need to upgrade the computer processing environment upon which the network is based: from the original Apple II systems to more modern and powerful microcomputers and software capable of handling the increased data processing and information requirements.

To meet the wide range of information needs that have evolved over the past 7 years, much of the processing done at the central WPACFIN office at the Honolulu Laboratory has been accomplished on non-Apple computer systems operating in the CP/M and MS-DOS environments using three different data base management packages and several graphics packages. Island fishery offices have operated entirely in the Apple-DOS environment. As user needs have become more sophisticated and information requirements have increased, so has the complexity of the computer processing required to meet those needs. The time has come to redesign the network, upgrade capabilities, and simplify processing. Through mutual agreement among the participants, the new operating environment will be NMFS-standard, MS-DOS, IBM-compatible systems using dBASE as the main data base management software. The "next generation WPACFIN" system will be an integrated, menu-driven, user-friendly environment easily operated and maintained by the noncomputer professional staffs of the island agencies. Converting to the new hardware and software will be a major undertaking accomplished in a stepwise and modular fashion as time and resources permit.

Six steps have been identified in the conversion process: 1) purchasing the new hardware and software, 2) training for operating and maintaining

the new hardware and software, 3) training for data base and software conversion, 4) converting data bases to the new data base management system, 5) converting or reprogramming the data base management functions for each data base system, and 6) redesigning and reprogramming the applications software for the creel survey data expansion systems.

The WPACFIN staff at the Honolulu Laboratory will be providing technical support, organization, coordination, and guidelines for accomplishing the conversion. Each fishery office is providing financial and personnel support through various non-WPACFIN channels, such as local funds; other federal sources, such as Interjurisdictional Fisheries Act or Fishery Management Council programs; and Pacific Island assistance programs, such as the South Pacific Commission and the Forum Fisheries Agency. To date, new hardware and software have been purchased or ordered by most agencies, and the others will follow suit as soon as funds are identified. An extensive training and conversion workshop is being planned and will be held at the Honolulu Laboratory as early as possible in 1989. Redesigning and reprogramming the system has begun at the central WPACFIN office, and the foundation for the major conversion effort is being laid. (D. Hamm (808) 943-1214)

PACIFIC FISHERIES ENVIRONMENTAL GROUP

Monterey, California

MATHEMATICAL MODELING AND DATA ANALYSIS

Long-Term Memory in the Ocean

Most of the recent work on the dynamics of the ocean and the effects the ocean has on fish population dynamics assumes that observations separated by a long time span are independent or nearly so. Even where nonstationary components are removed from the analysis by differencing or filtering, the underlying assumption of these filters is that the effect is relatively short term, that is the filter only includes relatively close (in time) observations. For example, with

monthly data it is not uncommon to take 12-th differences, defined as

$$\tilde{x}(t) = x(t) - x(t - 12).$$

An alternative way to represent this equation is by use of the backshift operator B defined as

$$B(x(t)) = x(t - 1)$$

so an alternative form of 12-th differencing is

$$(1 - B)^{12}x(t) = x(t) - x(t - 12).$$

The work of Lorenz, among others, strongly suggests that long-term memory exists in the atmosphere, and there is reason to believe the same is true for the ocean. Long-term memory in a time series is closely related to the ideas of "chaos" and "fractals" from deterministic dynamics. A series with long-term memory will tend to have the property of self-similarity, that is

$$x(t\lambda) \sim (\lambda)^d x(t)$$

for some value of d . Another way to view long-term memory is that the effect of a change at a given time t , instead of dying out relatively quickly, will persist for a long time. This can be viewed as "sensitivity to initial conditions." If the ocean has this property, and is influencing fish, then the presence of long-term memory has profound implications for our ability to forecast the consequences of our actions in a fishery.

An alternative way to represent this long-term property is through "fractional differencing," which can be written as

$$(1 - B)^d x(t) = \epsilon(t)$$

where $\epsilon(t)$ is a random variable, and here the differencing is defined as

$$(1 - B)^d = \sum_{k=0}^{\infty} \binom{d}{k} (-B)^k = 1 - dB - \frac{1}{2}d(1-d)B^2 - \frac{1}{6}d(1-d)(2-d)B^3 \dots$$

Unlike integral differencing, where only near-by terms are used in forming the differenced series, fractional differencing can include terms in the infinite past. The important property of fractional differencing is that processes with short-term memory have values of d such that $d < 0$, long-term memory processes have a value of d in the range $(0, 1/2)$, and the series has infinite variance if $d \geq 1/2$.

As part of his cooperative work with French scientists on fish dynamics in the Gulf of Guinea, Dr. Roy Mendelssohn, Operations Research Analyst, has estimated the value of d both for a shore station in the Ivory Coast and for an oceanic area where the Inter-Tropic Convergence zone (ITCZ) can be found. The value of d was estimated for sea surface temperature (SST) and salinity at the shore station, and for SST and the north-south and east-west components of the wind for the oceanic area (ITCZ), using two different methods of estimation (Table 1).

Table 1. Estimates of the fractional differencing parameter for selected environmental series of the Gulf of Guinea.

Series	Method of Estimation	
	Geweke & Porter-Hudak	Kashyap & Eom
Shore Station SST	0.4170	0.4426
Shore Station Salinity	0.4241	0.4486
ITCZ SST	0.6169	0.6728
ITCZ NS Wind	0.4036	0.4312
ITCZ EW Wind	0.0021	-0.0070

Nearly all of the series display long-term memory. Moreover, SST is a nearly infinite variance series. If this is actually the case, then mean-like statistics such as climatologies or anomalies would have little actual meaning, since there is no "normal" level to the series. Previous results by M. Philippe Cury, M. Claude Roy and Mendelssohn have shown that SST in the Gulf of Guinea reflects important processes in the Gulf of Guinea that have a major influence on fish dynamics in the Gulf. While much more research needs to be done before any definitive statements can be made, the initial results have profound and troubling implications for the management of fisheries in the region. (R. Mendelssohn (408) 646-331)

PELAGIC FISHERIES RESOURCES DIVISION

La Jolla, California

STOCK ASSESSMENT AND FISHERY IMPACT ANALYSIS PROGRAM

Southern California Striped Marlin Tagging

Preliminary records for the 1988 season indicates that about 642 striped marlin were caught by marine anglers off southern California, of which 19% (124 fish) were tagged and released during late summer and fall. Seventy-seven individual anglers reported tagging one or more striped marlin with Dave Denholm being the leading tagger, with 20 striped marlin tagged and released. Don McAdams was second with 5 fish, and Mort Barke and Roy Roberts were tied for third with 4 fish each. Of the captains, Doug Carson was the leader with 23 striped marlin tagged from his boat. Jack Bohannon was second with 9 fish, and Gary Graham third with 7 fish.

The number of marlin tagged and released in any one year appears to be related to the success in fishing. The better the fishing, the more anglers appear to be willing to tag and release their catch. The 1988 season started earlier than usual (July), with very good fishing, however, as the season progressed, catch rates dwindled. The 1988 catch was down about 8% from the long term average of about 800 fish per year. (J. Squire, FTS 893-7072)

Shark Workshop Planned

Work began in earnest on plans for a workshop that will review the methods available for assessment of coastal-pelagic shark populations. The Pelagic Fisheries Resources Division (PFRD) and the California Department of Fish and Game (CDF&G) are hosting the Shark Assessment Methods Workshop on February 15-16, 1989, at the Southwest Fisheries Center, La Jolla, California.

Growth and reproductive rates of most elasmobranch species are characteristically low, so the species are extremely vulnerable to exploitation and recruitment overfishing. The increased demand for shark as a food fish has put tremendous fishing pressure on most shark species and world-wide landings have increased sharply. Increased land-

ings on the U.S. west coast have raised concerns about depletion of the resource.

The goal of the workshop is to review available methods and biological information necessary for assessing the condition of exploited shark populations, and to serve as a first step in undertaking an evaluation of the condition of exploited shark populations along the U.S. west coast. (D. Holts, FTS 893-7186)

MULTISPECIES DATA COLLECTION AND EVALUATION PROGRAM

Sundown Set Analysis

Al Coan, Mathematical Statistician, Ken Wallace, Computer Programmer, and Al Jackson, Biological Technician have completed an analysis of sundown sets (sets that commence just before sundown and extend into night) made by United States tuna purse seiners fishing for tunas associated with dolphins in the eastern tropical Pacific. The analysis covers dolphin mortality during the period 1979 to 1988, data collected by the National Marine Fisheries Service and the Inter-American Tropical Tuna Commission. Results indicate that mortality rates (animals killed per set and per ton of yellowfin tuna caught) in sundown sets are significantly higher (2 to 8 times) than in sets made during the day. However, total dolphins killed is higher for day sets than for sundown sets, due to the higher frequency of day sets as compared to sundown sets.

Use of high-intensity floodlights during retrieval of the net to decrease mortality has been effective in reducing dolphin mortality in sundown sets, but still the rate is higher than in day sets. Prohibition of sundown sets occurring up to 90 minutes before sundown would decrease dolphin mortality, but will also result in losses of tuna catches. Reductions in dolphin mortalities appear possible by preventing problems that cause catastrophe kills in both day and sundown sets. (A. Coan, FTS 893-7079)

Data Submitted to Forum Fisheries Agency

The United States entered into a South Pacific Regional Tuna Treaty with 16 South Pacific Island states on June 15, 1988. The Treaty allows U.S. tuna seiners to be licensed to fish for tunas

within the Treaty area. As part of the Treaty, the vessels are required to submit logbook reports and unloading reports to the Southwest Region and the Forum Fisheries Agency (FFA). The Southwest Region is also sampling landings from licensed vessels for sizes of tuna caught and composition of fish species in the catch. All data collected are being processed by the Southwest Fisheries Center and made available to the FFA. Al Coan and Doug Prescott, Computer Programmer, transmitted the first series of computerized data to the FFA on December 15, 1988. Data included length samples, species composition samples, and logbooks received between September 21, 1988 and December 1, 1988. Future submissions will be made at 2 month intervals. (A. Coan, FTS 893-7079)

FISHERY MONITORING AND EVALUATION PROGRAM

U.S. Tuna Trade Summary for 1987 Completed

Wes Parks and Sam Herrick, with Pat Donley of the Southwest Region office, completed a review of U.S. tuna trade in 1987. The report is the fifth annual review of the U.S. tuna trade.

The review shows U.S. cannery landing receipts of imported and domestically-caught raw tuna were 532,700 short tons (st) in 1987, up 2% from 1986 level (Figure 1). U.S. cannery receipts of white meat tuna (albacore) were 104,200 st, down 10% from 1986. Imports made up 97% of the total landings. South Africa, a major transshipping center, was the principal shipping point for U.S. imports of raw white meat tuna.

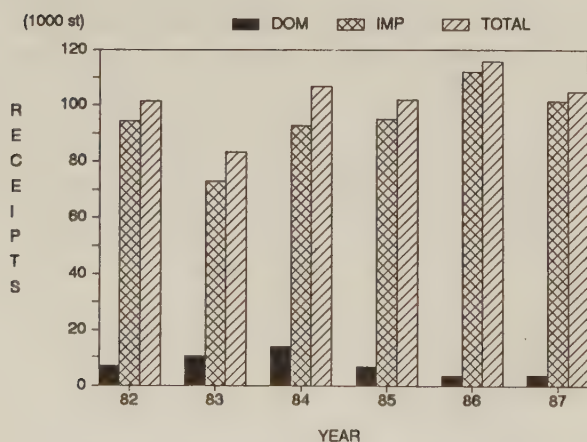


Figure 1. Landing receipts of white-meat tuna (albacore) by U.S. canneries, 1982-1987.

Total 1987 U.S. cannery landing receipts of raw, light-meat tuna were 428,510 st, up 5% from the 1986 level (Figure 2). Imports made up 41% of the total receipts. The Seychelles was the principal shipping point for U.S. imports of raw light-meat tuna.

The 1987 U.S. pack of canned tuna was 33.6 million standard cases, up 3% from 1986. The pack of white-meat tuna was 7.2 million standard cases, down 11% from 1986 (Figure 3); whereas the pack of light-meat tuna was 26.4 million standard cases, up 7% (Figure 4). U.S. imports of canned tuna in 1987 were 10.8 million standard cases, down 11% from the 1986 level--first recent year that imports have declined (Figure 5). Thailand, Taiwan and the Philippines were the major exporters of canned tuna to the United States in 1987.

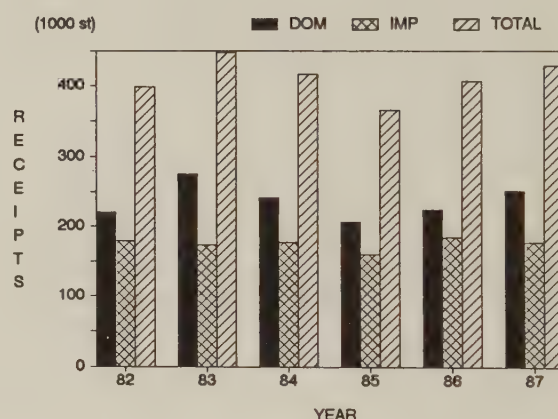


Figure 2. Landing receipts of light-meat tuna by U.S. canneries, 1982-1987.

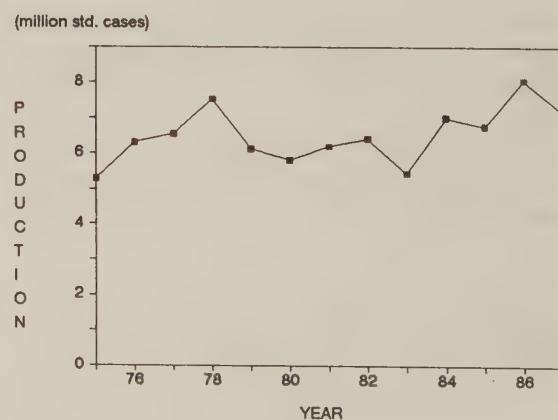


Figure 3. Production of canned white-meat tuna (albacore) by U.S. canneries, 1975-1987.

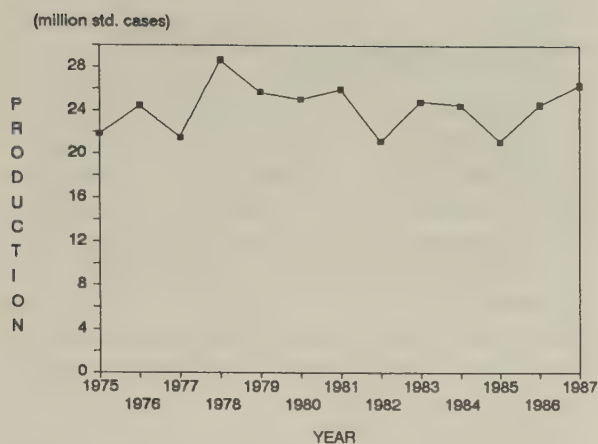


Figure 4. Production of canned light-meat tuna by U.S. canneries, 1975-1987.

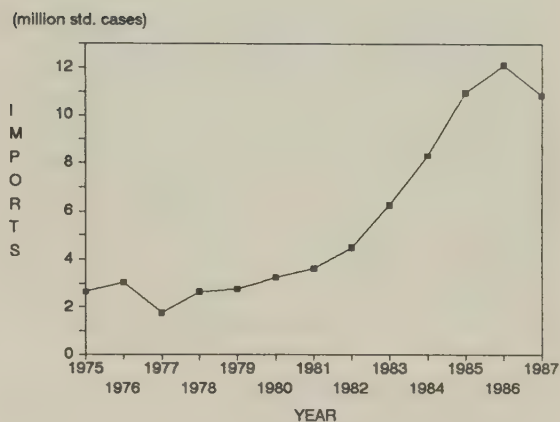


Figure 5. Imports of canned tuna by the U.S., 1975-1987.

(W. Parks, FTS 893-7074)

TIBURON LABORATORY

Tiburon, California

GROUND FISH COMMUNITIES INVESTIGATIONS

Changes in the Nearshore Environment Attributed to Sea Urchin Fishery

Major changes in the nearshore habitat along the Mendocino coast apparently have resulted from the recently developed fishery for red sea urchins, *Strongylocentrotus franciscanus*. This is a finding of the Groundfish Communities Investigations which have monitored the nearshore community in that area since 1981. Since urchin harvesting began there in 1985, Fishery Biologists Ted Hobson, Tony Chess and Dan Howard have noted a dramatic increase in area forested by the bull kelp, *Nereocystis leutkeana* (Figure 1), and at the same time a sharp decline

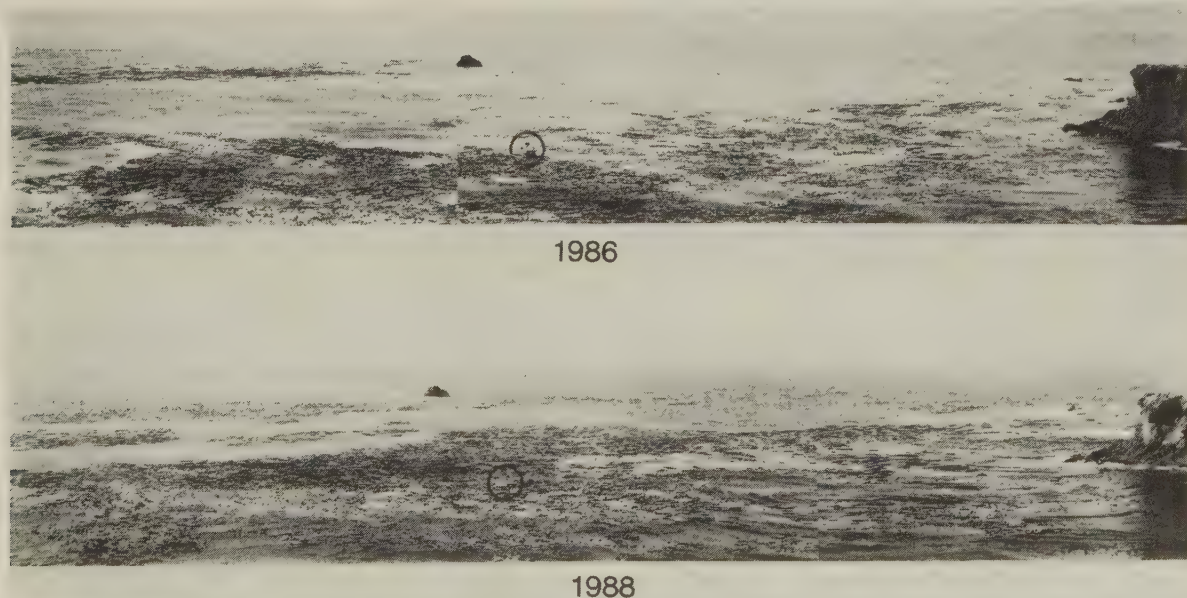


Figure 1. Expansion of area forested by bull kelp at the Mendocino study site after harvesting of the red sea urchin began there in 1985. Upper: September 24, 1986; lower: October 10, 1988. Circle encloses boat located above study site.

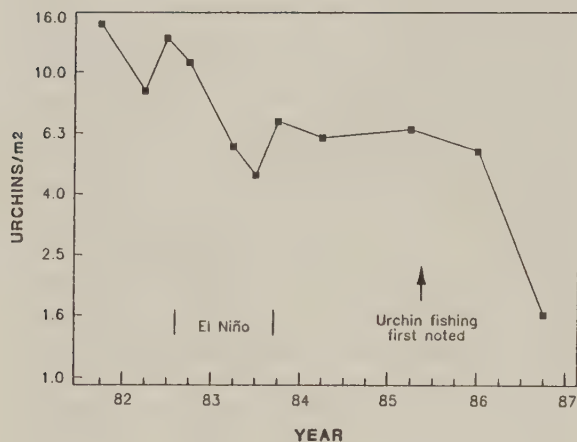


Figure 2. Numbers of red sea urchins, *Strongylocentrotus franciscanus*, counted in transect at Mendocino study site between October 1981 and November 1986.

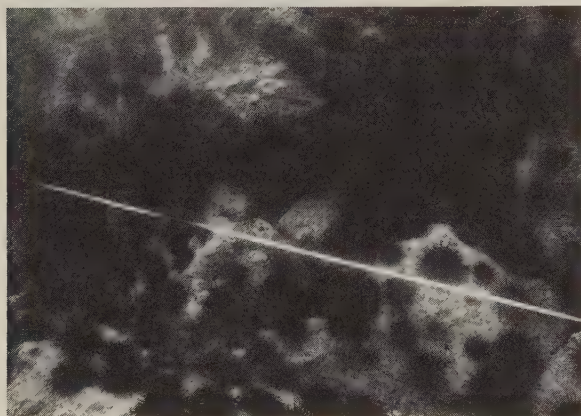


Figure 3. Red sea urchins along transect in the Mendocino study site during October 1981.

in the numbers of urchins (Figure 2). The bull kelp is a major food of the herbivorous red sea urchin, and apparently before the urchin fishery became established urchin grazing limited the kelp's distribution along the coast.

It is likely that, prior to harvesting, the great number of red sea urchins in this area (Figure 3) represented a condition that has existed only recently. Red sea urchins are major prey of sea otters, which once thrived here, and in areas where otters live today the exposed concentrations shown in Figure 3 could not exist. Thus, conditions that are developing here as urchins are removed by fishermen may be a return toward conditions that existed during an earlier time when urchins were removed by otters. (E. Hobson, FTS 556-0568)

Study of Continental Slope Fishes Expanded to Oregon

Study of community structure and trophic relations in fishes of the continental slope, a major activity of the Groundfish Communities Investigations since 1987, has been expanded to areas of the slope off northern Oregon. In a cooperative effort with investigators from the Northwest and Alaska Fisheries Center (NW&AFC), Fishery Biologist Wayne Samiere and Ltjg Kristie Miller, NOAA Corps, worked aboard the NOAA Ship *Miller Freeman* from November 25 to December 16. Distribution, abundance, and length-frequency data of slope species were collected as well as data on spawning behavior of several key commercial species.

With unusually mild weather, 62 bottom trawls were successfully completed at depths from 150 fathoms to 700 fathoms. From these collections, Samiere and Miller took a total of 1755 stomachs from five selected species. Their sample consisted of 359 sablefish, *Anoploploma fimbria*; 517 Dover sole, *Microstomus pacificus*; 353 shortspine thornyhead, *Sebastalobus alascanus*; 375 longspine thornyhead, *Sebastalobus altivelis*; and 151 deepsea sole, *Embassichthys bathybius*. Sablefish and Dover sole, the most numerous species in the trawl catches, and the targets of a recently developed slope fishery, are unlike the others in living at all depths sampled. (W. Samiere, FTS 556-0568)

GROUNDFISH ANALYSIS INVESTIGATIONS

Birthweeks Determined for Juvenile Shortbelly Rockfish

Beginning in 1983 the Groundfish Analysis Investigations has conducted annual cruises to sample the juvenile rockfish population off central California. Cruises are conducted in June with two additional cruises occurring in April of 1987 and 1988. One of the goals of the work is to relate reproductive success to oceanographic conditions. One of our approaches is to determine the timing of successful reproductive effort for major species and then, if the timing varies from year to year, compare the differences to oceanographic conditions.

Birthweeks of juvenile rockfish are determined from their otoliths using the aging techni-

ques developed at the La Jolla Laboratory for northern anchovy. Otoliths collected from juvenile shortbelly rockfish between 1983 and 1988 have been aged by David Woodbury of the Groundfish Analysis staff. The results of Woodbury's work indicated that in most years most successful reproduction occurs over a 3 to 4 week interval. Marked annual differences were found in the timing of reproductive success. In some years the peak occurred in January and in other years it was as late as April. These results indicate that there are sufficient differences to allow meaningful comparisons with oceanographic conditions.

Woodbury will be presenting his results in a talk at the Western Groundfish Conference January 9-11 in Monterey. He and Thomas Laidig anticipate completion of birthweek determinations of other important species of rockfish by December 1989. (D. Woodbury, FTS 556-0568)

GROUND FISH PHYSIOLOGICAL ECOLOGY INVESTIGATIONS

Coastwide Variation in Yellowtail Rockfish

In the summer of 1986, staff of the Groundfish Physiological Ecology Investigations (GPEI) accompanied NW&AFC personnel on their triannual

cruise off the west coast of California, Oregon, and Washington. The purpose of this work was to collect yellowtail, *Sebastes flavidus*; bocaccio, *S. paucispinis*; and widow rockfish, *S. entomelas*, from additional areas to compare with those collected from Cordell Bank off Bodega Bay, California. Approximately 20 of each species were collected from each of three areas: sections identified as (1) Monterey--California; (2) Columbia--Oregon and Washington; (3) Vancouver--Washington and British Columbia.

Fish were examined later at the Tiburon Laboratory and several measurements such as age, size, and condition of organs and parasites were made, similar to those on fish from Cordell Bank. Data collected comparing yellowtail rockfish with those collected at the same time at Cordell Bank have been analyzed and are summarized in Table 1 and Figure 4. The means shown in the Table and Figure were adjusted through covariance analysis for the effect of time collected, sex, and age. The fish were collected during July, August, and September 1986, a non-spawning period when feeding is normally optimal.

With the exception of disease, most of the characteristics of the fish we measured showed

Table 1. Summary of adjusted means for characteristics of yellowtail rockfish (*Sebastes flavidus*) collected from four geographic areas; July through September, 1986.

Characteristic (Adjusted mean)	Monterey	Bodega (Cordell)	Columbia	Vancouver
Age (Yrs)	8.8	13.8	11.3	14.6
Total Wet Weight (Gm)	1200.0	1213.0	1470.0	1675.0
Standard Length (Cm)	35.4	35.7	38.7	39.4
Body Depth (Cm)	10.9	11.7	12.5	13.2
Liver Wet Weight (Gm)	23.7	28.4	37.8	44.3
Mesenteric Fat Rank (1-5)	2.31	3.55	3.41	4.24
Gonad Wet Weight (Gm)	10.1	6.5	10.6	13.0
Rank Severity: (1-5)				
Heart Protozoan	1.27	1.72	1.21	1.03
Spleen Fungus	0.75	3.02	1.24	1.74
Kidney Fungus	0.12	3.11	1.18	2.00

¹*Henneguya sebastoda*

²*Ichthyophonus* sp.

Means adjusted through covariance analysis for effects of time sample, sex and age. Factor=Location.

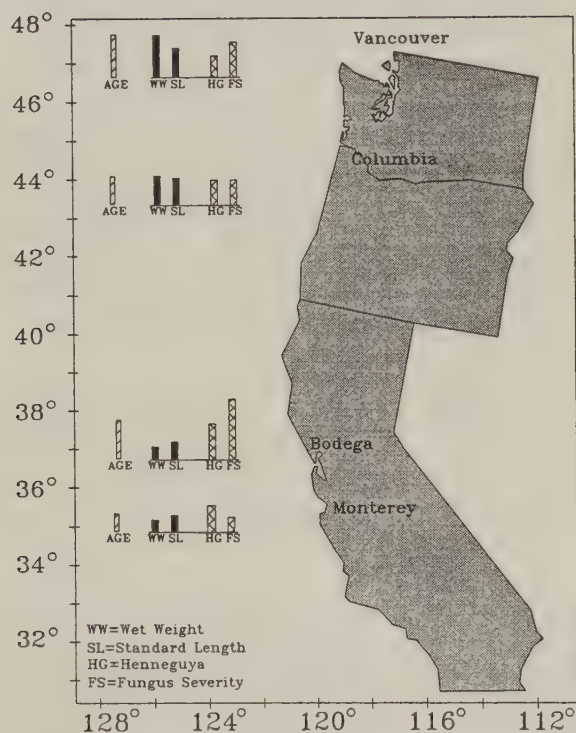


Figure 4. Comparison of coastwide variation of selected characteristics in yellowtail rockfish.

clinal variation, with larger, deeper-bodied fish further north (Figure 4). Fish from the northernmost location were also at a slightly later sexual maturation stage (Table 1, gonad wet weight).

Finally, significantly higher infections of the protozoan (*Henneguya sebastoda*) in the heart and of the fungus (*Ichthyophonus* sp.) in the spleen and kidney occurred in yellowtail from Cordell Bank. The black pigment patches (possibly melanomas) on the skin of yellowtail occurred only in fish from Cordell Bank and were not seen in fish sampled further north.

The sample sizes compared above are still small and final conclusions will not be made until additional geographic comparative sampling is completed. Initial analyses, however, indicate population differences from south to north, with the more peripheral southern populations of yellowtail rockfish showing indications of environmental stress, which may affect their condition, growth, and reproductive capacity. (M. Eldridge, FTS 556-0568)

INFORMATION TECHNOLOGY SERVICES

SWFC Local Area Network Progress and Plans

The installation of a 3COM Local Area Network (LAN) is underway at the La Jolla Laboratory of the SWFC. The LAN is expected to entirely replace the Center's Molecular 32X multi-user super microcomputer. In addition to improving upon services currently available on the 32X, it will offer a variety of new services. Until the 32X becomes redundant, the two systems will be run in parallel.

A single LAN server and partial cabling (seven segments) were installed by PacTel Infosystems during May and June of 1988. This was in keeping with the original plan to begin by testing the LAN in a controlled, prototype setting. It was felt this would minimize risk on the early side of the learning curve and provide an opportunity to exercise better control by allowing for growth to occur in phased increments.

The LAN now consists of a network server with a shared hard disk and tape backup system (a 3Server3), 4 "hot" segments of thin ethernet, a 15 segment isolating repeater, an uninterruptible power supply, 12 connected PC nodes, a communications server, modems, and a series of printers. The network now provides connected users with access to WordStar Version 4.0, WordPerfect Versions 4.2 and 5.0, Smartcom II, and 3+MAIL Email with "seamless" routes to other 3COM networks (e.g. the NMFS Washington, DC office). Additionally, users are provided with daily disk backup and restore services and efficient file exchange capabilities.

Plans for the future include the addition of a second server (3COM Series 401) and additional "hot" cable segments, interconnection via 3+ROUTE of the La Jolla and Honolulu 3COM LANs, interconnection via 3+REMOTE of the La Jolla LAN and PCs in Terminal Island and Tiburon, the connection of 15-20 new PC workstations, the addition of 3+MAC to support a mixed environment of both PCs and Macintosh computers, the addition of a shared PostScript printer, the installation of dBASE IV+ LAN Version, and a shared spreadsheet.

The development, management, and maintenance of the LAN are the responsibilities of ITS. New users are required to pay only the cost of the ethernet adaptor card needed to connect their PCs to the thin coaxial ethernet cabling. Users interested in LAN connection should contact Al Coan and/or Rich Charter. Discussions are now underway between Frank Ralston, the network administrator, and the Division data managers in order to establish a priority for connecting the next round of 15-20 users. (F. Ralston, FTS 893-7062)

STATUS OF PUBLICATIONS

Published

- Ambrose, David A. and H. Geoffrey Moser. 1988. Rearing, development, and early life history of the California needlefish, *Strongylura exilis*. *Revue fr. Aquariol.* 15(2):43-48.
- Fertilized eggs were obtained from field-caught specimens of California needlefish, *Strongylura exilis*, and incubated in an experimental aquarium to obtain developmental series of embryos, larvae, and juveniles. The spherical eggs are 2.4-2.7 mm in diameter and have 28-40 elongate filaments evenly spaced over the shell. At hatching (10-19 days after fertilization) the larvae have functional eyes, jaws, digestive tracts and caudal fins and are covered with xanthic and melanistic pigment. Newly hatched larvae fed immediately on larvae of brine shrimp and grew rapidly (1 mm/day). Late larvae and early juveniles continued rapid growth on a diet of frozen adult brine shrimp and chopped squid. Allometric growth of the upper and lower jaws produces a "halfbeak" stage which reaches a maximum at 24 mm body length when the relative difference in "beak" length is 27% of body length. During the developmental period the sheath of melanophores and xanthophores which covers the body changes to a zonal pattern consisting of a greenish black dorsum and two lateral silvery zones.
- Au, D. W. and R. L. Pitman. 1988. Seabird relationships with tropical tunas and dolphins, p. 174-212. In: Joanna Burger (ed.), *Seabirds and other marine vertebrates - competition, predation and other interactions*. Columbia Univ. Press, New York.
- Boehlert, G. W. 1988. Seamount acoustic scattering: nocturnal emissions or organismal activities. *Eos Trans. Am. Geophys. Union* 69(49):1619, 1628.
- Boggs, C. 1988. Forecasting skipjack tuna availability in Hawaii. *Tuna Newsl.* 91:5-7. (U.S. National Marine Fisheries Service, Southwest Fisheries Center, La Jolla.)
- DeMaster, Douglas P. and Jeannie K. Drevenak. 1988. Survivorship patterns in three species of captive cetaceans.
- Survival rates for three species of captive cetaceans are reported, based on records of dates of capture, birth, and death of individual animals. The annual survival rate was 0.93 for bottlenose dolphins and killer whales and 0.94 for white whales. Confidence limits of these estimates are discussed. Differences in survival rates between institutions were significant for bottlenose dolphins only. Calf survival for bottlenose dolphins was lower than non-calf survival. Survivorship of male killer whales was significantly less than survivorship of female killer whales; sex-specific survival rates were similar to the other two species. Estimates of average or maximum longevity alone were not useful in comparing rates of survival. Because survival in the first year of captivity may be lower than subsequent years, estimates of the expected lifespan, based on data from the first few years of captivity, may be biased.
- Gooding, R. M., J. J. Polovina and M. D. Dailey. 1988. Observations of deepwater shrimp, *Heterocarpus ensifer*, from a submersible off the island of Hawaii. *Mar. Fish. Rev.* 50(1):32-39.
- Holts, David B. 1988. Review of U.S. west coast commercial shark fisheries. *Mar. Fish. Rev.* 50(1):1-8.
- The economic history of elasmobranch fisheries generally indicates the need for a high catch per unit of effort because of fluctuating commercial value and market demand. Growth and reproduction in most elasmobranch species are extremely slow, and as a result there is a close relationship between stock size and recruitment. Because of this relationship, only a small amount of that stock is available to support a sustained fishery. The increased demand for shark as a food fish has put tremendous fishing pressure on some species. Two of these, the common thresher, *Alopias vulpinus*, and Pacific angel shark, *Squatina californica*, have not responded well to this increased pressure. Several other stocks appear healthy even though some warning signs of overfishing are appearing. The need for reduced fishing on some stocks and increased monitoring of catch for others is warranted.
- Lamadrid-Rose, Y. and G. W. Boehlert. 1988. Effects of cold shock on egg, larval, and juvenile stages of tropical fishes: Potential impacts of ocean thermal energy conversion. *Mar. Environ. Res.* 25:175-193.
- Ocean thermal energy conversion (OTEC) facilities will bring large volumes of deep, cold water to the surface, where it will be mixed with

warm surface water after the utilization of the thermal differential. Mixing of these two water types will result in exposure of larval and juvenile fishes entrained in the warm water intake to lowered temperatures. A time course of cold shock from simulated entrainment was used to determine potential effects upon egg and larval mahimahi, *Coryphaena hippurus*, manini, *Acanthurus triostegus*, and juvenile striped mullet, *Mugil cephalus*. Experiments were designed to test varying exposure times and temperature changes upon different early life stages of tropical fishes.

Earlier stage eggs were more sensitive to temperature shock, with mortality increasing with increasing delta T as compared to controls; exposure time, however, did not exert a significant effect. Significant excess mortality for all stages of eggs occurred at the range of times and temperatures used in the experiments, although in some cases, these exceed values proposed in current OTEC engineering plans. For mahimahi larvae, excess mortality increased with age to values higher than for latest stage eggs, but we consider this to be caused by stress associated with yolk exhaustion. A single size range of juvenile mullet was exposed to the same experimental protocol as the eggs and larvae. Although exposure time was not significant, delta T had a significant effect upon mortality, and there was a significant interaction between exposure time and delta T.

Watson, C., R. E. Bourke and R. W. Brill. 1988. A comprehensive theory on the etiology of burnt tuna. Fish. Bull., U.S. 86:367- 372.

Over the past 14 years, the Hawaii handline fishery has experienced phenomenal growth in the catch for large yellowfin tuna, *Thunnus albacares*, and bigeye tuna, *Thunnus obesus*. These fish are primarily caught for the sashimi (raw consumption) market but have been continually plagued with a product quality problem known as "burnt tuna" or, in Japanese, yake niku. Not only does this problem significantly reduce the value of the catch, it also limits export markets and expansion of this low-capital, high-return fishery to other areas of the Pacific. Previous research and suggestions for mitigating burnt tuna have centered on the hypothesis that it is caused by high muscle temperature and low pH, which is the result of a violent struggle during capture.

A new, more comprehensive hypothesis is presented: Burnt tuna is actually caused by the postmortem activation of enzymes known as calcium-activated proteases and by the enhancement of the effect of these enzymes by high blood catecholamine levels. Previously unexplainable observations, such as the propensity of female fish to become burnt more often during the summer months, the efficacy of brain destruction in preventing burnt tuna, and the lack of effect of cooling on the incidence of burnt tuna, are explainable in light of this new hypothesis.

Southern, Sarka O., Peter J. Southern and Andrew E. Dizon. 1988. Molecular characterization of a cloned dolphin mitochondrial genome. J. Mol. Evol. 28:32-42.

DNA clones have been isolated that span the complete mitochondrial (mt) genome of the dolphin, *Cephalorhynchus commersonii*. Hybridization experiments with purified primate mtDNA probes have established that there is close resemblance in the general organization of the dolphin mt genome and the terrestrial mammalian mt genomes. Sequences covering 2381 bp of the dolphin mt genome from the major noncoding region, three tRNA genes, and parts of the genes encoding cytochrome b, NADH dehydrogenase subunit 3 (ND3), and 16S rRNA have been compared with corresponding regions from other mammalian genomes. There is a general tendency throughout the sequenced regions for greater similarity between dolphin and bovine mt genomes than between dolphin and rodent or human mt genomes.

Approved, Science and Research Director, SWR

Bakun, Andrew and Richard H. Parrish. Comparative studies of coastal pelagic fish reproductive habitats--a tropical western ocean boundary example: The Brazilian sardine (*Sardinella aurita*). For consideration for publication in the Journal du Conseil.

Barlow, Jay. A birth-interval model for estimating reproductive rates from re-sight data. For publication in Special Issue, International Whaling Commission.

Barlow, Jay and Peter Boveng. Modeling age-specific mortality for marine mammal populations. For consideration for publication in Marine Mammal Science.

Boehlert, George W. Tropical fisheries ecology? For consideration for publication in American Scientist (book review).

Hobson, Edmund S. and Daniel F. Howard. Mass strandings of juvenile shortbelly rockfish and Pacific hake along the coast of northern California. For consideration for publication in California Department of Fish and Game.

Humphreys, Robert L., Jr., Robert B. Moffitt and Michael P. Seki. First record of the bigeye sand tiger shark *Odontaspis noronhai*. For consideration for publication in the Japanese Journal of Ichthyology.

Hunter, J. Roe, John L. Butler, Carol Kimbrell and Eric A. Lynn. Bathymetric patterns in size, age, water

- content, caloric density and biomass of Dover sole, *Microstomus pacificus*. For consideration for publication in Fishery Bulletin, U.S.
- Lo, Nancy C. H., John R. Hunter and Roger P. Hewitt. Precision and bias of estimates of larval mortality. For consideration for publication in Fishery Bulletin, U.S.
- Lowry, Mark S., C. W. Oliver, C. Macky and J. B. Wexler. The feeding habits of the California sea lion, (*Zalophus californianus californianus*) at San Clemente Island, California from September 1981 through September 1986. For consideration for publication in Fishery Bulletin, U.S.
- MacFarlane, R. Bruce, H. Rodger Harvey, Michael J. Bowers and John S. Patton. Serum lipoproteins in striped bass (*Morone saxatilis*): Partial characterization and effects of starvation. For consideration for publication in the Canadian Journal of Fisheries and Aquatic Sciences.
- Mendelssohn, Roy. Relating fisheries to the environment in the Gulf of Guinea: Information, causality and long-term memory. Symposium paper, ORSTOM.
- Perrin, William F., Nobuyuki Miyazaki and Toshio Kasuya. A dwarf form of the spinner dolphin (*Stenella longirostris*) from Thailand. For consideration for publication in Marine Mammal Science.
- Skillman, Robert A. Status of Pacific billfish stocks. For publication in the Proceedings of the Second International Billfish Symposium.
- Stevens, Elizabeth G., William Watson and H. Geoffrey Moser. Development and distribution of larvae and pelagic juveniles of three kyphosid fishes (*Girella nigricans*, *Hermosilla azurea*, and *Medialuna californiensis* off California and Baja California. For consideration for publication in Fishery Bulletin, U.S.
- Wyllie Echeverria, Tina and William H. Lenarz. Survey of the abundance and distribution of pelagic young-of-the-year rockfishes off central California. For consideration for publication as a NOAA Technical Report.

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- Herrick, Samuel D. and Daniel D. Huppert. 1988. Economic impacts associated with changes in landings of California entangling net fisheries 1981-1986. SWFC Admin. Rep., La Jolla, LJ-88-27, 11 p.
- Kleiber, Pierre and Elizabeth F. Edwards. 1988. A model of tuna vessel and dolphin school movement in the eastern tropical Pacific Ocean: Technical description of model. SWFC Admin. Rep., La Jolla, LJ-88-28, 18 p.

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